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T R E A T I S E  
O F T H E  
Animal Oeconomy.

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By *BRYAN ROBINSON*, M. D.

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In TWO VOLUMES.

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The THIRD EDITION, with great Additions.

To which is added,

A LETTER to Dr. *Cheyne*, containing an Account of the Motion of Water through Orifices and Pipes; and an Answer to Dr. *Morgan's* Remarks on Dr. *Robinson's* Treatise of the Animal Oeconomy.

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V O L. II.

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M D C C X X X V I I I.





## Advertisement.

**I**N this Continuation of the Animal Oeconomy, I have given an Account of the Tenacity of the Blood compared with the Strength of the Fibres; of the vibrating Motions of the Fibres, and Motions of the Fluids consequent thereon; and of the proper Methods of regulating Excesses and Defects in any of these, in order to reduce them to a natural State; whether the Deviation from that State constitutes an acute or a chronic Disease.

Aug. 22. 1737.

# Advertisement

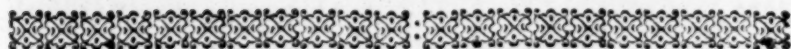
IN the Examination of the Animal  
Economy, I have given an A-  
ccount of the Quantity of the Blood  
circulated, and the Strength of the  
Fibres, of the circulating Matters of the  
Lymph, and Mucous of the Fluids  
respective to them; and of the Pro-  
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nical Disease.

Aug. 11. 1757.



## SECTION V.

*Of the Tenacity of the Blood compared with the Strength of the Fibres; of the vibrating Motions of the Fibres and the Motions of the Fluids consequent thereon; and the proper Methods of regulating the Excesses and Defects in any of these in order to reduce them to a natural State.*



### PROPOSITION XLI.

**T**HE Tenacity of the Blood is increased by Things which strengthen the Fibres, and lessened by Things which weaken them.

X X 2

I. Cold

1. Cold strengthens and Heat weakens animal Fibres, by *Prop.* 37. And Cold increases and Heat lessens the Tenacity of the Blood. For Cold condenses and Heat rarefies the Blood: But when the Blood is condensed, its Particles are brought nearer together, and when it is rarefied, they are removed farther asunder; and when the Particles of the Blood are brought nearer together, their attractive Forces are increased, and when they are removed farther asunder, those Forces are lessened, all attractive Forces being stronger at less Distances than at greater; and when the attractive Forces of the Particles of the Blood are increased or lessened, the Cohesion of those Particles, which measures the Tenacity of the Blood, is increased or lessened: And therefore Cold increases and Heat lessens the Tenacity of the Blood.

These



These Effects of Heat and Cold on the Blood are the same with their Effects on other Bodies. Heat promotes Fluidity very much by lessening the Tenacity of Bodies. It makes many Bodies fluid which are not fluid in Cold, as Metals, Butter, Fat of Animals, Jelly, and Soap; and increases the Fluidity of tenacious Liquids, as of Oil, Balsam, Honey, Mucilage, and a strong Solution of Soap in Water. Mucilage and a strong Solution of Soap in Water, which are very tenacious and ropy when cold, presently lose their Tenacity when set on the Fire, but do not lose it while they continue cold, though they be strongly agitated with the Hand or any other Way.

2. Driness strengthens and watry Moisture weakens animal Fibres, for the very same Reason that Cold strengthens and Heat weakens them.

For



For all Fibres both vegetable and animal swell in wet Weather, and contract in dry Weather : But when Fibres swell by the Force of watry Moisture imbibed, their component Particles are removed farther asunder, and of Consequence, the attractive Powers of those Particles, and the Strength of the Fibres depending on them, are lessened; and on the contrary, when the Fibres contract on the Evaporation of the imbibed Moisture, their Particles are brought nearer together, and their attractive Forces, on which the Strength of the Fibres depends, are increased. By the same way of reasoning, the Blood must be more or less tenacious, as it abounds less or more with Water. For a greater Proportion of Water in the Blood removes its strongly attracting Particles to greater Distances from one another, and consequently, lessens  
their

their attractive Powers and the Tenacity of the Blood depending on those Powers; and a lesser Proportion of Water in the Blood has a contrary Effect on its Tenacity. And therefore, Driness increases and watry Moisture lessens the Tenacity of the Blood.

3. Oils, ardent Spirits, and all Liquors abounding with oily Parts strengthen animal Fibres, and warm Water and alcalious Spirits weaken them, by *Table 1. Prop. 35.* And by Experiments made on the Blood it has been found, that Oils, ardent Spirits, Balsams, and Bitters increase the Tenacity of the Blood; and that warm Water and alcalious Spirits lessen it. Hence it is, that Spirit of Harts-horn, when taken in too large a Quantity, has been found to occasion Hæmorrhages; and that the Blood coagulated by the Bites of venomous Creatures recovers its natural

tural Fluidity by large Doses of volatile alcalious Spirits given in Fountain Water, without any other Remedy.

4. The Acid of the Air strengthens animal Fibres, by the Observations on the *Tables* in *Prop.* 35. And that it gives a Tenacity and Consistence to the Blood, may be gathered from its Manner of acting both on the Salts and oily Parts of the Blood.

The Acid of the Air, after it is taken into the Blood, unites with its Salts, and thereby renders them grosser and less volatile than before; in like Manner as Spirit of Sea-salt which is an acid Spirit, and Spirit of Soot which is a volatile alcalious Spirit, being mix'd together unite and compose the Particles of Sal-armoniac, which are grosser and less volatile than before: But volatile alcalious Spirits, which are composed

posed of volatile alcalious Salts and Water, greatly attenuate and thin the Blood, by *N.* 3: And therefore the Acid of the Air, by changing the Salts of the Blood as they become volatile by Heat or Putrefaction into a Kind of Sal-armoniac, and thereby lessening their Volatility, keeps up a Tenacity in the Blood.

Hence the Blood will be apt to abound with volatile Salt, when it is not sufficiently impregnated with this Acid; and it may not be sufficiently impregnated with this Acid, when the Air is not sufficiently stock'd with it, or when too small a Quantity of it is taken into the Blood in a given Time by Respiration. The Air contains less of this Acid in hot Weather than in cold Weather, Part of it being destroy'd in hot Weather by the great Quantities of sulphureous Steams and vo-



latile Salts, which are then raised from the Earth and the putrified Substances of Vegetables and Animals; and Persons who are inactive, by breathing less receive less of it into their Blood in a given Time than Persons who use Exercise. Hence putrid Fevers are much more frequent in Summer and hot Climates than in Winter and cold Climates; and oftener seize sedentary Persons than Persons who use Exercise. Hence likewise the Flesh of Fish, from their breathing less and consequently taking less of the Acid of the Air into their Blood in a given Time than Land Animals, is of a more alcalious Nature and corrupts sooner than the Flesh of Land Animals. In a *Phthisis* the Blood abounds with volatile Salts, and constant Riding (by which the Blood is plentifully supply'd with this Acid)

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is found to be of the greatest Service in its Cure.

The Acid of the Air, by giving Strength to the Fibres and a Tenacity to the Juices, greatly preserves animal Substances from Putrefaction. For those Substances putrify soonest, whose Fibres are weakest and Fluids least tenacious. Young Meats of all Kinds, whether Flesh or Fish, corrupt sooner than old; the Flesh of Fish corrupts sooner than the Flesh of Land Animals; the softest and moistest Flesh of all Kinds corrupts generally soonest; the Flesh of Land Animals, kill'd soon after they have been much heated by hunting or hard driving, corrupts much sooner than the Flesh of Animals not so used; and all Sorts of Flesh corrupt sooner in hot Weather than in cold Weather, in moist Weather than in dry Weather, and in a stagnating Air than in an Air agi-

tated by Wind. The Salts of the Blood are too volatile in putrid Fevers, and accordingly, their Cure is most successfully effected by gentle Sweats and Liquids impregnated with Acids. Gentle Sweats carry off Part of the volatile Salt, and acidulated Liquids correct the Remainder. *Sydenham* cured a Pestilential Fever by Sweating. And the Child-bed Fevers of Women are best cured by keeping them constantly in a gentle Sweat, by slightly-acidulated Drinks taken warm. The great Heat, occasioned by the *Labour*, volatilizes the Salt and Oil of the Blood, and thereby makes Child-bed Fevers to be of the putrid Kind.

On the contrary, the Blood is more than ordinarily tenacious and viscid in inflammatory Fevers, which are most frequent in cold frosty Weather, in which the Air abounds most with acid Particles, and the  
Blood

Blood of Consequence is most saturated with them; and oftener seize Persons who use much Exercise than Persons who are sedentary. That the Tenacity of the Blood in these Fevers arises in a good measure from its being impregnated with too great a Quantity of Acid, may be farther confirmed from their Cure, which is best effected, after due Evacuati-  
ons in the Beginning, by alcalious Powders and Spirits, watry Liquors drunk warm, and warm Applicati-  
ons of a watry Nature to the inflamed Parts. These Things, from their Power of destroying Acids, of weakening the Fibres, and attenuating the Blood by their Warmth and watry Nature, are the proper Remedies in inflammatory Fevers.

The Acid of the Air gives a farther Tenacity and Consistence to the Blood, by its Action on the oily Parts of the Blood. The Fat of  
Land



Land Animals is harder, and consequently more tenacious than the Fat of Fish which runs much to Oil; and the former imbibe more of the Acid of the Air in a given Time than the latter. The oily Part of the Aliment, by being mixed with the Acid of the Air in the Blood, regains that Part of its strengthening Power which it loses in the Intestines by being mix'd with the Bile, by *Obs. 5. Prop. 35*. These Instances prove, that the Tenacity of the oily Part of the Blood, and consequently the Tenacity of the Blood which depends much on its oily Part, is increased by the Acid of the Air united with it. The Acid of the Air, when it first enters the Blood, attenuates and dissolves it with Heat, by *Prop. 24*. But after that Action is over, it unites with the oily Parts of the Blood, and by increasing their attractive Powers  
gives

gives it a Tenacity and Consistence.

From what has been said we may understand, whence it is, that the Discharges by Perspiration, Urine and Stool, are more uniform and regular and less apt to run into Excesses and Disproportions to one another, in Persons who use constant and moderate Exercise in the open Air, than in Persons who are indolent and sit much within Doors. The former imbibe more of the Acid of the Air in a given Time, and consequently acquire a greater Tenacity and Consistence of the Blood and Juices than the latter; but the more tenacious and consistent the Blood and Juices are, the less apt their Parts will be to separate and run off by excessive and disproportionate Discharges. The Discharges are very irregular in Hysterical and Hypochondriacal Persons, who

who commonly are sedentary and inactive; and nothing restores them to a just Proportion and Uniformity so much as constant and moderate Exercise in the open Air.

5. A strong Solution of common Salt in Water is a great Strengthenener of animal Fibres, by *Tab. 1. Prop. 35.* And that common Salt increases the Tenacity of the Blood, appears from its preserving the Flesh and Juices of Animals from Putrefaction.

6. Animal Fibres grow harder and stronger by Age, by *Prop. 36.* And we find by Observation, that the Blood of old Animals is more thick and tenacious than the Blood of young Animals. The Increase of Strength in animal Fibres by Age is to be ascribed to an Increase of the Quantity of the Particles of Light in their Composition, by *Schol. Prop. 36.* And the Increase  
of

of the Tenacity of the Blood by Age must be owing to the same Cause which increases the Strength of the Fibres. For the Juices and Blood of old Plants and old Animals contain more Oil and less Water in their Composition than the Juices and Blood of young Plants and young Animals; but Oil contains much more Light in its Composition than Water, Quantity for Quantity.

Now since in the Instances above alledged of Heat and Cold, Driness and Moisture, Oils, ardent Spirits, Balsams and Bitters, volatile and alcalious Substances, Water, the Acid of the Air, a strong Solution of common Salt, and the Rays of Light; I say, since in these Instances, those Things which increase the Strength of animal Fibres increase likewise the Tenacity of the Blood; and those Things which lessen the

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Strength



Strength of animal Fibres lessen also the Tenacity of the Blood; and since these are the Things which principally affect the Strength and Tenacity of the Fibres and Blood, and into which almost all Things which are any way capable of affecting the Strength and Tenacity of the Fibres and Fluids may be resolved; it is therefore reasonable to infer the Truth of the *Proposition* universally.

*Cor. 1.* Hence, the Fibres are weaker and the Blood less tenacious in Persons who live upon Vegetables and Water, than in Persons who live upon Flesh Meat and fermented Liquors; and hence also, the Fibres are weaker and the Blood less tenacious, *cæteris paribus*, in Persons who are inactive than in Persons who use Exercise.

*Cor.*

*Cor. 2.* Hence, when the Tenuity of the Blood is too great or too little, we may know how to change it; for it will be lessened by Things which weaken the Fibres, and increased by Things which strengthen them.

#### SCHOLIUM.

The Tables in *Prop. 35.* exhibit the strengthening Powers of various Fluids compared with one another, but do not shew, which of those Fluids do really strengthen or weaken the Fibres in the Bodies of living Animals. To know this, we must first know the strengthening Powers of the animal Fluids, which may be had from the Strengths of Hairs wet with them, and then by comparing those Powers with the strengthening Powers of other Fluids we may

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know, whether those other Fluids will strengthen or weaken the Fibres. To know the strengthening Powers of the animal Fluids, I took the Strengths of Hairs wet with the *Serum* of the Blood, the Saliva and Urine of a healthful Man, and with the Gall of a Sheep and of a Pig, when all these Fluids were cold; and found the Strengths of the Hairs wet with the three first to be as the Numbers 13888, 13244, 13950, and the Strengths of the Hairs wet with the two last to be equal, and as the Number 13888, which is a little less than the Strength of the Hair wet with the Gall of a Sheep in the first *Table*. From these Experiments it appears, that the strengthening Powers of the animal Fluids, when cold, are nearly equal to one another, and all nearly equal to 14285, which expresses the strengthening Power of cold Water. Hence

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we may infer, that the strengthening Powers of the animal Fluids, when warm in the Bodies of living Animals, are nearly equal to the strengthening Power of Water under the same Degree of Warmth. And since cold Water is much more strengthening than hot Water, and by Consequence, the animal Fluids when cold more strengthening than the same Fluids warm, we must allow, that all the Fluids of *Tab. 1.* (except volatile alcalious Spirits) when taken cold into the Bodies of Animals, are of a strengthening Nature; and that the only Fluids which are remarkably weakening are volatile alcalious Spirits, and Water or watry Liquors taken hot.

I shall here set down the Strengths of Hairs wet with a few Fluids not mentioned in the *Table.* The Strengths of three Hairs wet with  
*Spiritus*



*Spiritus salis volatilis oleosus*, *Elixir proprietatis*, and *Aqua mirabilis*, were as the Numbers 65625, 65223, and 52083. The Strengths of four Hairs wet with strong Decoctions of the *Peruvian Bark*, *Gentian Root*, *Chamomile Flowers*, and *Oak Bark*, in Water, were as the Numbers 23809, 20000, 15873, and 15625. The Strengths of two Hairs, wet with *Elixir vitrioli Mynsichti* and *Tinctura martis Mynsichti*, were equal and as the Number 98000. The Strength of a Hair wet with *German Spa Water* as the Number 25000. And the Strength of a Hair wet with a strong Solution of *Opium* as the Number 15151. These Experiments were made at the same Time with those, from which I composed the first *Table* in *Prop.* 35. and with Hairs of the same Person; all which Hairs were equally strong when dry.

## PROPOSITION XLII.

**I***F an animal Fibre be extended and contracted alternately, without Intermission or Interval between the two Motions, by the alternate Action of an extending and contracting Force, if the two Forces be equal, and if all the Extensions and Contractions caused by those equal Forces be small, equal in Length, and described in equal Times; the vibrating Motion of the Fibre generated in a given Time, will be nearly as the Quantity of Matter in the Fibre and Length of one Extension taken together directly, and as the Time of one Extension inversely; or nearly, as the Quantity of Matter in the Fibre, the extending Force and Length of the Fibre taken together directly, and as the*

*the Resistance given to the Motion the Strength of the Fibre and Square of its Diameter, taken together inversly.*

*If M denote the vibrating Motion of the Fibre generated in a given Time, q the Quantity of Matter in the Fibre, E the Length and t the Time of one Extension, l the Length d the Diameter and S the Strength of the Fibre, F the extending Force, and R the Resistance given to the Motion; then M*

*will be nearly as  $\frac{qE}{t}$ , or nearly as  $\frac{qFl}{RSd^2}$ .*

For, the Extensions and Contractions being small by Supposition, the vibrating Motion of the Fibre generated in a given Time, will be nearly as the Quantity of Matter in the Fibre and the Sum of all the Extensions and Contractions described in that Time, taken together: But the Extensions and Contractions

tractions are all equal and all described in equal Times by Supposition; and consequently, the Sum of all the Extensions and Contractions in the given Time will be as the Sum of all the Extensions; and the Sum of all the Extensions will be as the Length of one Extension and Number of Extensions in the given Time taken together; and the Number of Extensions in the given Time will be inverſly as the Time of one Extension: And therefore, the vibrating Motion of the Fibre generated in a given Time will be nearly as the Quantity of Matter in the Fibre and Length of one Extension taken together directly, and as the Time of one Extension inverſly; that is,  $M$  will be nearly as  $\frac{qE}{t}$ . The Length of a ſmall Extension of an animal Fibre is nearly as the extending  
A a a                      Force,



Force, the Time of the Extension, and Length of the Fibre taken together directly, and as the Resistance given to the Motion, the Strength of the Fibre, and Square of its Diameter taken together inversely, as I have found from Experiments; that is,  $E$  is nearly as  $\frac{F t l}{R S d^2}$ : And therefore,  $M$  will be nearly as  $\frac{q F l}{R S d^2}$ .

*Cor. 1.* If the Quantity of Matter in an animal Fibre, its Diameter, and Length be all given; the vibrating Motion generated in a given Time will be directly as the extending Force, and inversely as the Resistance given to the Motion, and the Strength of the Fibre, taken together. If  $q$ ,  $d$  and  $l$  be given,  $M$  will be nearly as  $\frac{F}{R S}$ .

To

To know how to increase or lessen the vibrating Motion of the Fibres in animal Bodies, and in what Cases and under what Circumstances it will be proper to do the one or the other, are Matters of the utmost Importance in Physick.

To know how to increase or lessen the vibrating Motion of the Fibres in animal Bodies, we must know the extending Force, the Resistance given to the Motion, and the Strength of the Fibres; the Things which regulate that Motion, when  $q$ ,  $d$ , and  $l$  are given.

The principal extending Forces of the Fibres in animal Bodies are Heat, the *Stimulus* of irritating Matter, and the Power of the Soul.

That Heat has a Power of causing a vibrating Motion in the Fibres of Animals, will appear from the following Observations. The Pulse is fuller and quicker, and con-

A a a 2                      sequently,

sequently, the vibrating Motion of the Fibres of the Heart and Arteries greater, in Bodies heated by Exercise or an ardent Fever, than in Bodies chill'd by cold Air or the cold Fit of an Ague. The Fulness and Quickness of the Pulse lessen, as Bodies heated by Exercise grow cool. And in a Heart which continues to beat for some time after it is taken out of the Body, the Pulsations lessen both in Magnitude and Frequency as the Heat lessens, and cease when the Heat ceases. The Operation of vomiting and purging Medicines is increased by Heat and lessened by Cold : But Vomiting and Purging are caused by a strong vibrating Motion of the Fibres of the Stomach and Intestines : And therefore, Heat increases and Cold lessens the vibrating Motion of the Fibres of the Stomach and Intestines. Perspiration is much greater when the  
Skin

Skin is warm than when it is cold. The *Catamenia* are increased by Heat, and lessened, nay often entirely stopped, by Cold. In a Word, the progressive Motion of all the animal Fluids, which Motion is all caused by the vibrating Motion of the Fibres, is increased by Heat and lessened by Cold.

The Discharges caused by the stimulating Particles of evacuating Medicines of all Kinds, of Poisons, and of vegetable and animal Substances dissolved by Putrefaction, shew that the *Stimulus* of irritating Particles has a Power of causing a vibrating Motion in the Fibres; for all progressive Motions of the Fluids, and all Discharges consequent on those Motions, are caused by the vibrating Motions of the Fibres.

The Soul has a great Power over the Motion of the Heart, by *Prop.* 21; and a still greater Power over  
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the Muscles designed for voluntary Motion, by every one's Experience; and besides, by a great Variety of powerful Instincts it regulates the Motions of the Fibres and Fluids, when they happen to be disturbed; and exerts such Efforts as are necessary to preserve animal Life. And therefore, the Soul has a Power of causing a vibrating Motion in animal Fibres.

The Resistance given to the vibrating Motion of the Fibres in Animals arises, either from the Fluids to be moved by that vibrating Motion, or from an Impediment or Check given to the Extension of the Fibres. An Increase of the Quantity or Tenacity of the Fluids, or an Impediment given to the Dilatation of the Vessels by Fat or any other Cause, will increase the Resistance; and a Diminution of the Quantity or Tenacity of the Fluids,  
or

or a Removal of an Impediment given to the Dilatation of the Vessels, will lessen the Resistance.

The Strength of the Fibres may be known from the Food, Exercise, Age, and Habit of the Body. The Fibres are stronger in Persons who live upon a strengthening Diet, than in Persons who live upon a weakening Diet; in Persons who live upon Flesh Meats and fermented Liquors, than in Persons who live upon Vegetables and Water. We may know the Strength of the Fibres as far as it depends on Diet, by *Prop. 35.* The Fibres are stronger in Persons who use Exercise, than in Persons who are inactive; and in Persons who use Exercise, the Fibres are generally stronger or weaker, as the Exercise requires more or less Motion of the Muscles. The Fibres of old Bodies are stronger than the Fibres of young Bodies. And the Fibres  
are

are stronger in lean Bodies than in fat Bodies, because the Fibres are drier in lean Bodies than in fat Bodies, and drier Fibres are always stronger, *ceteris paribus*, than Fibres which are moister.

When the extending Force of animal Fibres, the Resistance given to their vibrating Motion, and their Degree of Strength are once known; we may by this *Corollary* know, how to increase or lessen the Motion. The vibrating Motion will be increased or lessened, by increasing or lessening the extending Force, or by lessening or increasing the Resistance, or the Strength of the Fibres. M will be increased or lessened, by increasing or lessening F, or by lessening or increasing R or S.

To know, in what Cases and under what Circumstances it will be proper to increase or lessen the vibrating Motion of the Fibres, when  
it

it happens to differ from that which obtains in a State of Health, we must know the Cause of that Motion, and the Intent of Nature in raising it. If the Cause be irritating Matter, and the Intent of Nature in raising a strong vibrating Motion of the Fibres be to have that Matter carry'd out of the Body; the Motion must not be check'd, but be suffer'd to continue, and be increased, if there be Occasion and the Strength can bear it, till that End is attained. And after that, if the vibrating Motion of the Fibres does not cease of itself, it may be safely stopped by Things which strengthen the Fibres and by *Opium*. For tho' *Opium* has no strengthening Quality in it self, yet forasmuch as it eases Pain, and checks Discharges, it powerfully lessens the vibrating Motion of the Fibres. The Truth

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of



of these Things will appear from the following Instances.

A great vibrating Motion of the Fibres of the Stomach and Intestines, excited by vomiting and purging Medicines, Poisons, corrupted Aliment, or sharp Humours secerned from the Blood, must, if the Strength can bear it, be suffer'd to continue, and be increased (if there be Occasion) by watry Liquors drunk plentifully and warm, till the irritating Matter is carried out of the Body by Vomit and Stool. And when this End is attained, if the vibrating Motion does not cease of it self, it may then be safely quieted by strengthening Things and *Opium*. A strong Solution of common Salt in Water, given in small Quantities, powerfully stops vomiting; and it does it more effectually with an Addition of *Opium*. And compound Waters, which

which are ardent Spirits, and *Opium* powerfully stop purging. This Method has been found successful in a *Cholera morbus*, and in a *Diarrhæa* and *Dysentery* in the Beginning. But if a *Diarrhæa* or *Dysentery* have been of some Continuance, the Flux must be stopped, not barely by strengthening the Fibres, lest Inflammations and Mortifications should ensue, but chiefly by turning the Course of the Fluids from the Intestines to other Parts of the Body (the Manner of doing which shall be shewn hereafter) and likewise by correcting the ill Qualities of the Blood, which is generally much vitiated in long Fluxes of the Belly.

A great vibrating Motion of the Fibres of the Heart and Arteries, occasioned by the Heat and Foulness of the Blood in Fevers, must not be check'd, unless some noble Part be

B b b 2            inflamed;

inflamed; but be kept up by Warmth and watry Liquids taken in proper Quantities, that the febrile Matter may be rightly concocted, intirely separated from the Blood, and discharged out of the Body in a *Crisis*. That the Blood is foul at the coming on of Fevers, appears from the Foulness of the Discharges in the *Crisis*, and the Termination of the Fever by those foul Discharges. And that Heat and Motion are the chief Instruments Nature uses to concoct the febrile Matter, and fit it to be separated from the Blood, and carried out of the Body by the Discharges, appears from those Fevers terminating soonest in which the Heat and Motion of the Blood are greatest, and those on the contrary latest in which the Heat and Motion of the Blood are least. The Heat and Motion of the Blood may be known by the Heat of the Skin all  
over

over the Body, and the Magnitude and Frequency of the Pulse.

*Cor. 2.* If the Quantity of Matter in the Fibre, its Diameter and Length, the extending Force, and the Resistance to the Motion, be all given; the vibrating Motion of the Fibre generated in a given Time will be inverſly as the Strength of the Fibre. If  $q$ ,  $d$ ,  $l$ ,  $F$  and  $R$  be given,  $M$  will be as  $\frac{1}{S}$ .

The Operation of a given Dose of a vomiting or purging Medicine, cauſed by the given *Stimulus* of the Medicine, is much increaſed in one and the ſame Body by weakening the Fibres with Water and watry Liquors drunk warm. The Ancients prepared Bodies for vomiting and purging, by thinning the Humours and weakening the Fibres; both of which are neceſſary to make even a  
ſtrong



strong Medicine produce a large Discharge in Persons of robust and strong Fibres.

*Cor. 3.* If the Quantity of Matter in the Fibre, its Diameter and Length, the extending Force, Extension and Resistance, be all given; the Time of an Extension will be as the Strength of the Fibre. If  $q$ ,  $d$ ,  $l$ ,  $F$ ,  $E$  and  $R$  be all given,  $t$  will be as  $S$ .

For since the Extension produced by a given extending Force in a given Time, is greater in one and the same Fibre when it is weak than when it is strong; it follows, that the same extending Force will take up less Time in causing a given Extension in the same Fibre when weak than when strong; and consequently, the Time of producing a given Extension will vary with the Strength of the Fibre.

That

That the vibrating Motion of animal Fibres is made quicker by Things which weaken the Fibres, and slower by Things which strengthen them, may be farther illustrated from the following Experiments.

I wet a Hair with Water, extended it when wet 90 Divisions of the Scale, then let it dry, and kept it 24 Hours in that extended State. At the End of that Time, I removed all but 7 Grains of the Force which kept it extended, and it contracted 13 Divisions in half an Hour, 5 more in 3 Hours, 5 more in 9 Hours and 40 Minutes, and 1 more in 12 Hours; so that in 24 Hours it contracted only 24, which was little more than a fourth Part of the whole Extension. I then apply'd a dry Cloth hot, and repeated the Application as often as the Cloth grew cool, on which it contracted

19 Divisions in 15 Minutes, and on wetting it with cold Water 43 more in 4 Minutes, and  $1\frac{1}{4}$  more in 10 Minutes; so that by the Assistance of Warmth and Water it contracted near thrice as much in half an Hour, as it contracted in 24 Hours before.

I wet another Hair with Water, extended it when wet 90 Divisions of the Scale, then let it dry, and kept it 10 Days in that extended State. At the End of that Time, I took away all but 7 Grains of the Force which kept it extended, upon which it contracted 13 Divisions in half an Hour, 6 more in 4 Hours, 7 more in  $21\frac{1}{2}$  Hours, 5 more in one natural Day and 2 Hours, 4 more in 4 Days and 16 Hours,  $2\frac{1}{2}$  in two Days and one Hour, and  $\frac{1}{2}$  more in one Day and three Hours; so that in 10 Days it contracted only 38, which was not half of the whole

whole Extension. I then held it to the Fire, upon which it contracted 12 in 3 Minutes; and 39 in 3 Minutes more, on wetting it with cold Water.

I again wet the Hair, used in the last Experiment, with Water, and kept it 10 Days extended 90 Divisions of the Scale. I then suffer'd it to contract, and it contracted 47 Divisions in 9 Days. During the Time of its Contraction the Weather was wet, which made it to contract more in 9 Days, than it did in 10 Days in the last Experiment when the Weather was drier. After that I held it to the Fire, on which it contracted  $9\frac{1}{2}$  in 6 Minutes. Then I wet it with Oil, on which it was so far from contracting that it extended about 2 Divisions in 2 Hours, and continued so extended 24 Hours. I then wash'd the Hair with a Feather dipt in cold Water, and found, that

C c c

tho'



tho' it did not move immediately, yet in 7 Minutes from the Time I began to wash it, it contracted  $30\frac{1}{2}$ , and 2 more in 20 Minutes.

From these Experiments, Warmth and Water accelerate, and Oil retards the vibrating Motion of animal Fibres.

*Cor. 4.* If the extending Force be as the Quantity of Matter in the Fibre and the Length of one Extension, taken together; the vibrating Motion generated in a given Time will be as the extending Force directly, and the Time of an Extension inverſly. If  $F$  be as  $qE$ ,  $M$  will be as  $\frac{F}{t}$ .

The Force of the Heart is the extending Force of the System of Arteries, and if this Force be proportional to the Quantity of Matter contained in the Coats of the System

System and the Extension of the System in one Systole of the Heart, taken together; the vibrating Motion of the System generated by the Force of the Heart in a given Time, will be directly as the Force of the Heart and Number of Pulses in that Time taken together; or directly, as the Capacity of the System and Number of Pulses in that Time taken together, by *Prop.* 12; or directly, as the Quantity of Blood which flows through the Heart or Aorta in that Time, by *Cor.* 1. *Prop.* 14; or as the Sum of the Discharges by Perspiration Urine and Stool in that Time, by *Cor.* 3. *Prop.* 31; that is, retaining the Symbols used in the *Propositions* concerning the Motion of the Blood and the Discharges, M will be as FP, or as  $D^2LP$ , or as  $D^2V$ , or as Z. All this may be allowed, since it is very rational to think that the vibrating Motion of

the arterial System, and Quantity of Blood which flows through it in a given Time, are always proportional to each other.

*Cor. 5.* If the Quantity of Matter in the Fibre be as the Resistance given to its Motion, if the Square of its Diameter be as its Length, and the Time of an Extension be as its Strength; the Quantity of its vibrating Motion generated in a given Time, will be directly as the extending Force, and inverfly as the Time of an Extension. If  $q$  be as  $R$ ,  $d^2$  as  $l$ , and  $t$  as  $S$ ;  $M$  will be as  $\frac{F}{t}$ .

*Cor. 6.* If the Length of an Extension be as the extending Force, and the Square of the Diameter of the Fibre be as its Length, or the Diameter and Length be both given;



ven; the Time of an Extension will be as the Resistance and Strength of the Fibre, taken together. If  $E$  be as  $F$ , and  $d^2$  as  $l$ , or  $d$  and  $l$  be both given;  $t$  will be as  $RS$ .

In the vibrating Motion of the System of Arteries in a living Animal, the Time of one Extension is the Time of one Pulse, and the Time of one Pulse is inversely as the Number of Pulses in a given Time; that is,  $t$  is as  $\frac{1}{P}$ : And therefore, if this *Corollary* obtains in the System of Arteries, the Number of Pulses in a given Time will be as the Resistance given to the Force of the Heart and Strength of the Fibres of the System, taken together inversely; that is,  $P$  will be as  $\frac{1}{RS}$ ; or, the Pulse will be quickened by Things which lessen the Resistance and weaken the Fibres. Heat increases the Force of the Heart, makes  
the



the Pulse greater and quicker, lessens the Resistance, and weakens the Fibres; all which Heat ought to do, to make this *Corollary* obtain in the Motion of the Blood of one and the same Body.

A greater Degree of Heat by increasing the Force of the Heart, and enlarging the Capacity of the System of Blood-vessels, will increase the Velocity of the Blood by *Prop. 12.* And that a bare Dilatation of the Blood-vessels by Heat, without an Increase of the Force of the Heart, will increase the Quantity of Blood which flows through one and the same Part of the System in a given Time, follows from *Prop. 1;* and may likewise be gathered from some Experiments made by Mr. *Hales.* For he found, “ that a  
“ given Quantity of warm Water,  
“ impelled by its own Weight,  
“ pass’d quicker through the same  
“ Blood-

“ Blood-vessels than the same Quan-  
 “ tity of cold Water ; that on re-  
 “ peating the Experiments with  
 “ each several times, the warm Wa-  
 “ ter pass’d still quicker and the  
 “ cold Water still slower in each  
 “ succeeding Trial ; and that the  
 “ warmer the Water was, the quick-  
 “ er it pass’d ; that common Bran-  
 “ dy, and Decoctions of the *Pe-*  
 “ *ruvian* Bark, Chamomile Flow-  
 “ ers, and Cinnamon, pass’d all  
 “ much slower than warm Water ;  
 “ and the Decoction of the *Peru-*  
 “ *vian* Bark slower than the rest ;  
 “ and that they all passed still slow-  
 “ er in each succeeding Trial.

That a given Quantity of Fluid,  
 impell’d by a given Force, should pass  
 through the same Vessels in a longer  
 or a shorter Time, must be owing  
 either to a Change in the Capacity  
 of the Vessels, or to a Difference in  
 the Nature of the Fluid moved  
 through

through them. A given Quantity of the same Fluid impelled by a given Force, will, from the Nature of the Motion of Fluids through Pipes, pass through the same Vessels in a less Time when they are wider than when they are narrower. And if the Capacity of the Vessels continue the same, a given Quantity of a different Fluid, impell'd by a given Force, will pass through them in a less or a greater Time, as the Fluid is less or more tenacious, or as the Attraction between it and the Side of the Vessel is weaker or stronger.

*Cor. 7.* If the Quantity of Matter and vibrating Motion of the Fibre be both given; the Length of one Extension will be as the Time in which it is made. If  $q$  and  $M$  be given,  $E$  will be as  $t$ .

To

To have the vibrating Motion of one and the same System of Arteries given, the Frequency of the Pulse must be inverſly as its Magnitude, or the Pulse muſt become quicker as it becomes leſs, and on the contrary. For in this Caſe, E expreſſes the Magnitude and  $t$  the Time of a Pulse: But  $t$  is as  $\frac{1}{P}$ : And therefore,  $P$  is as  $\frac{1}{E}$ .

This Property of the Pulse never obtains in a natural and healthful State of the Body, nor ever with Exactneſs in a diſeaſed State. And yet the Pulse is always quickened on a great Diminution of its Magnitude, as will appear by the following Experiments and Obſervations.

*Lower* on bleeding Dogs to Death. found, that after they had loſt much Blood, and began to grow faint, the Pulse grew quicker, on the Veſſels growing empty, and the remaining  
D d d
Blood



Blood not being sufficient to fill the Ventricles of the Heart; and that it grew quicker and smaller continually from the continual Loss of Blood, till the Motion of the Heart ceased for want of Blood to support it.

Mr. *Hales* on bleeding Horses to Death observed, that on tying the Horse to make the Experiment, the Pulse was quickened from 36 or 38 to above 60 Beats in a Minute; that as the Horse grew faint from the Loss of Blood, the Pulse grew still quicker, and beat above 100 times in a Minute before he expired, which happened after he had lost 16 or 17 Quarts of Blood; that when he came near the Time of expiring, he breathed quick, sigh'd deeply, struggled violently, and fell into cold clammy Sweats; that the projectil Force of the Heart, measured by the Height to which it threw the Blood

Blood up a Tube fastened to the Orifice, grew less and less, but irregularly on Account of the Sighs and Struggles which always increased it; and that this Force at the Time of expiring was not above a fourth Part of what it was at the Beginning.

I have ever observed the Pulse to be quick, when it becomes very small by great Losses of Blood. A Woman, from a very great Loss of Blood from the *Uterus*, had a Pulse extremely quick, but so very small, that it could scarcely be felt, with great Faintness, Restlessness, Sighing and Coldness of the Limbs; all which Symptoms vanished in a little Time by Rest and Nourishment.

The Pulse is quick and small in Bodies chill'd by cold Air, and in the cold Fit of an Ague, in malignant Fevers, most Convulsions, and a Coagulation of the Blood by Poisons. Hence we learn, that an

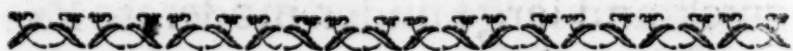
Incraffation of the Blood and Contraction of the Blood-vessels, when they happen in any considerable Degree, make the Pulse quick and small: But an Incraffation of the Blood and Contraction of the Blood-vessels lessen the Motion of the Blood: And therefore, the Pulse becomes quick and small on a considerable Diminution of the Motion of the Blood. The Pulse is very quick and small, and the Motion of the Blood languid, in dying Persons. The Pulse was very quick, little and creeping, in a Man in whom the Valves of the Aorta were found ossified and stood half open. By this Fault in these Valves, part of the Blood which was thrown out of the Left Ventricle in each Systole, was forced back again into the Ventricle by the Contraction of the Aorta; which must first have given a Check to the Motion of the Blood through the Lungs,



Lungs, and thereby gradually to the Motion of the Blood through the whole Body ; the Consequence of which was an *Asthma* and Dropsy, of which he died about the Age of 50. The Pulse is quick and small, when the Cavities of the Heart, or of the large Blood-veffels terminating in them, are much contracted by Polypuses, or by Compression. And it becomes very quick, small and trembling, on tying or cutting the principal Nerves of the Heart. *Galen* observed the Pulse to become quick and large under moderate Exercise, and a moderate Use of a warm Bath ; but quick and small under much and violent Exercise, and an immoderate Use of a warm Bath ; and he likewise observ'd it to be quick and small, when the vital Faculty (i.e. the Power which moves the Blood) is dissolved by want of Nourishment, the Malignity of Diseases, the



Violence of the Passions, the Violence or Continuance of Pain, and immoderate Evacuations. From these Observations it is evident, that the Pulse becomes quick and small on any great Diminution of the Blood's Motion, from whatever Cause that Diminution arises. The Quickening of the Pulse on a great Diminution of the Blood's Motion, seems to be intended by Nature to raise the languid Motion, thereby to preserve Life as long as is possible.



### PROPOSITION XLIII.

**I***N the vibrating Motion of an animal Fibre, if the Times of an Extension and Contraction be small and equal, if the Lengths of an Extension and Contraction be small, if a Resistance*

*sistance be given to the Contraction, and the contracting Force be equal to the Difference between the extending Force and the Resistance; the Contraction in Proportion to the Extension, will be nearly equal to the Difference between the extending Force and Resistance in Proportion to the extending Force; that is,  $\frac{C}{E}$  will be nearly equal to  $\frac{F-R}{F}$ .*

For small Spaces described in equal Times are nearly as the moving Forces by which they are described, from the Nature of Motion: But by Supposition, an Extension and Contraction are small, are described in equal Times by the extending and contracting Forces, and the contracting Force is equal to the Difference between the extending Force and the Resistance: And therefore

therefore  $\frac{C}{E}$  will be nearly equal to  $\frac{F-R}{F}$ .

*Cor. 1.* If the Resistance be nothing, the Contraction will be equal to the Extension. If  $R$  be 0,  $\frac{F-R}{F}$  will be 1; and consequently,  $C$  will be equal to  $E$ .

When I made the Experiments from which I composed the Tables in *Prop. 35*, after I had taken the Extension caused by a Weight of 300 Grains in two Minutes, I removed all the extending Weight but 7 Grains, and let each Hair contract under that small Resistance during an equal Time. Upon comparing the Contractions with their respective Extensions, I found them to be nearly equal; only the Contraction in Proportion to the Extension, was a little less in the Hairs wet  
with

with strengthening Fluids, than in the Hairs wet with weakening Fluids; it was less in the Hair wet with Oil-Olive than in the Hair wet with hot Water, in the Proportion of 8554 to 9875; and less in all the Hairs when dry, than in the Hair wet with hot Water, in the Proportion of 9400 to 9875. The Resistance being 7 Grains and the extending Force 300,  $\frac{F-R}{F}$  was 9766.

*Cor. 2.* If the Resistance compared with the extending Force be of some Magnitude, the Contraction will be nearly as much less than the Extension, as the Difference between the extending Force and the Resistance is less than the extending Force; C will be nearly as much less than E, as  $F-R$  is less than F.

The mean Extension of two dry Hairs, caused by a Weight of 300  
                                   E e e                                   Grains



Grains in two Minutes of Time, was  $5\frac{1}{2}$ ; and their mean Contractions in an equal Time, under the Resistances of 100 and 200 Grains, was  $3\frac{1}{2}$  and  $1\frac{7}{8}$ : Whence their mean Contractions in Proportion to their mean Extensions under those Resistances were 6363 and 3409.

The mean Extension of two Hairs wet with Oil-Olive, caused by the same Weight of 300 Grains in two Minutes, was  $5\frac{13}{16}$ ; and their mean Contractions in an equal Time, under the same Resistances of 100 and 200 Grains, were  $3\frac{1}{2}$  and  $1\frac{15}{16}$ : Whence their mean Contractions in Proportion to their mean Extensions under those Resistances, were 6021 and 3333.

The mean Extension of two Hairs wet with Water caused by the same Weight of 300 Grains in two Minutes (the mean Extension of which Hairs when dry was  $5\frac{1}{2}$ ) was  $55\frac{1}{32}$ ; and

and their mean Contractions in an equal Time, under the same Resistances of 100 and 200 Grains, was  $27\frac{23}{32}$  and 15 : Whence their mean Contractions in Proportion to their mean Extensions under those Resistances, were 5037 and 2732.

In all these three Cases,  $\frac{F-R}{F}$  was 6666 when the Resistance was 100, and 3333 when the Resistance was 200. So that this *Corollary* obtains nearly in dry Fibres, and Fibres wet with Oil; but does not obtain in Fibres wet with Water. For in Fibres wet with Water,  $\frac{C}{E}$  is always considerably less than  $\frac{F-R}{F}$ .

For the same Reason that of Fibres of the same Strength when dry, those which are dry or wet with Oil contract more in Proportion to their Extension, than those which are wet with Water; I suppose it is, that of

E e e 2                  Fibres

Fibres of different Strengths when dry, those which in that State are stronger will, when they are wet with Water and the Resistance compared with the extending Force is considerable, contract more in Proportion to their Extension, than those which are weaker; as will appear by the following Experiment.

When the extending Force was a Weight of 200 Grains, and the Resistance a Weight of 160; the Contractions in Proportion to the Extensions of three Hairs, whose Strengths when dry were as the Numbers 2285, 1951 and 1600, were 1465, 1392 and 1127 when the Hairs were wet with Water. In this Case,  $\frac{F-R}{F}$  was 2000.

*Cor. 3.* If the Resistance with respect to the extending Force be great, and both the Resistance and the

the extending Force increase or decrease in the same Proportion; the Contraction will be nearly as the Extension. If  $\frac{R}{F}$  be great, and R be as F, C will be nearly as E. For F being as R,  $\frac{F}{R}$  and consequently  $\frac{F-R}{F}$  will be as 1: And therefore, C will be nearly as E.

When the extending Force was a Weight of 200 Grains, and the Resistance a Weight of 160; the mean Contractions in Proportion to the mean Extensions of Hairs, when dry, wet with Oil, and with Water, were 1719, 1411 and 1302.

When the extending Force was a Weight of 300 Grains, and the Resistance a Weight of 240; the mean Contractions in Proportion to the mean Extensions of the Hairs used in the last Experiment, when dry,  
wet



wet with Oil, and with Water, were 1909, 1601 and 663.

When the extending Force was a Weight of 400 Grains, and the Resistance a Weight of 320; the mean Contractions in Proportion to the mean Extensions of Hairs, which were of the same Strength when dry as those used in the two preceding Experiments, were 501, 596 and 464 when they were dry, wet with Oil, and with Water.

In each of these 3 Experiments  $\frac{F-R}{F}$  was 2000.

By these Experiments when  $\frac{R}{F}$  is great and given, F must have a certain Magnitude to make this *Corollary* obtain nearly even in dry Hairs.

*Cor. 4.* The Difference between the Extension and Contraction in Proportion to the Extension, is equal to the Resistance in Proportion to the  
the

the extending Force; that is,  $\frac{E-C}{E}$  is nearly equal to  $\frac{R}{F}$ .

If the Resistance be as the extending Force, the Difference between the Extension and Contraction will be nearly as the Extension by this *Corollary*; that is, if  $R$  be as  $F$ ,  $E-C$  will be nearly as  $E$ ; or in other Words, if  $\frac{R}{F}$  be given,  $\frac{E-C}{E}$  will be nearly given; as will appear by the following Experiments.

$\frac{E-C}{E}$  taken at a Medium from Hairs when dry, wet with Oil, and with Water, was 9531, 8588 and 8833, when the extending Force and Resistance were 200 and 160; was 8093, 8398 and 9263, when the extending Force and Resistance were 300 and 240; and was 9497, 9403 and 9535, when the extending Force and Resistance were 400 and

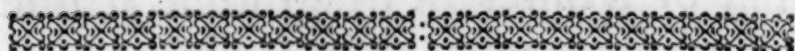
and 320. In all these Cases  $\frac{R}{F}$  was 8000.

*Cor. 5.* If the Contraction be equal to the Extension, and the Resistance be of some Magnitude, the Force which causes the Extension will be nearly equal to the Difference between the extending Force and the Resistance, that is, nearly equal to  $F-R$ . For the Contraction and Extension being equal by Supposition, the contracting and extending Forces must be equal: But the contracting Force is nearly equal to  $F-R$  by the Experiments in the foregoing *Corollaries*: And therefore, the Force employ'd in causing the Extension will be nearly equal to  $F-R$ .

In the vibrating Motion of the Arterial System, if the Extension and Contraction be always equal,  
but

but of a different Magnitude at one Time from what they are of at another ; the extending and contracting Forces will be always equal, but of a different Magnitude at those different Times : And consequently, by this *Corollary*, the Resistance given to the extending Force of the System will be always equal to the Resistance given to the contracting Force ; that is, the Resistance given to the Force of the Heart which extends the Arteries, will be always equal to the Resistance given to the contracting Power of the Arteries. And this will obtain, whatever be the Nature of the Resistance, whether it arises from the Quantity or Tenacity of the Blood, from a Change made in the Capacity of the System, or from any other Cause.





## PROPOSITION XLIV.

**I***F perfect Health in a human Body of a given Stature necessarily requires a certain and determinate Proportion of the Quantity of Blood to the Weight of the Body; then a grown Person who constantly enjoys good Health must always be nearly of the same Weight.*

For it has been found by Observation, that animal Bodies have more Blood when lean than when fat, when lighter than when heavier; and by Consequence, a certain and determinate Proportion of the Quantity of Blood to the Weight of the same grown Body necessarily requires, that both the Quantity of Blood and Weight of the Body should be

be given: But by Supposition, perfect Health in a Body of a given Stature requires a certain and determinate Proportion of the Quantity of Blood to the Weight of the Body: And therefore, a grown Person who constantly enjoys good Health must always be nearly of the same Weight.

*Proof by EXPERIMENTS.*

*Sanctorius* found by Statical Experiments, “ that Health is more  
 “ firm and lasting in a Body whose  
 “ Weight is neither increased nor  
 “ diminished in the Course of many  
 “ Years, than in a Body whose  
 “ Weight changes annually; that  
 “ Health will continue good even  
 “ to extream old Age, if Bodies be  
 “ always kept of the same Weight  
 “ in the four Seasons of the Year;  
 “ that Bodies whose Weights in the  
 “ Course of a Year are much in-  
 F f f 2 “ creased

“ creased and diminished, are in  
“ great Danger; that by how much  
“ greater the Difference of Weight,  
“ whether Increase or Diminution,  
“ is in the Space of a Year, by so  
“ much worse is the Condition of  
“ that Body; that Bodies have no  
“ Disease in Autumn, if they be not  
“ heavier in Autumn than in Sum-  
“ mer; and that Bodies are not  
“ troubled with any Disease in Au-  
“ tumn, if they be clad warmly,  
“ use Diureticks, and keep them-  
“ selves of the same Weight as be-  
“ fore.” And that these Observa-  
tions are true, I am fully satisfied  
from my own Experience in this  
Kingdom.

*Cor. 1.* The Food of a grown  
Body which is constantly in good  
Health, must always be nearly equal  
to its Discharges; otherwise, the Bo-  
dy

dy cannot always be nearly of the same Weight.

*Cor. 2.* An Equality between the Food and Discharges in a grown Person who constantly enjoys good Health, necessarily requires, that when there is an Increase or Diminution of the one, there should be an equal Increase or Diminution of the other.

For Instance, when the Discharges are lessened by Cold, Disuse of Exercise, or any other Cause, the Food must be equally lessened ; and when the Food is increased, the Discharges must be equally increased ; otherwise, Persons will be apt to fall into Diseases. The Quantity of Food may be lessen'd, either by taking less Food daily, or by fasting ; and the Sum of the Discharges may be increased, either by using more Exercise, or by evacuating Medicines. Fasting is preferable



preferable to Evacuations caused by Medicines, because it does not raise that Irregularity and Disproportion in the Discharges, which are often produced by evacuating Medicines used frequently and for a long Time.

The Quantity of Food requisite to keep a grown Body in Health, ought to be such as gives no Uneasiness to the Body in concocting it, and can be carry'd off without any unusual or critical Discharge. *Sanc- torius* found this to be true by Experiments, as appears from the following Aphorisms. “ The most  
“ healthful Quantity of Food for  
“ every one is that, which can be  
“ concocted without any Uneasi-  
“ ness; as it will be, if as much as  
“ is taken in be carried off by the  
“ Discharges; which may be known  
“ by weighing. The most health-  
“ ful Quantity of Food is that, after  
“ taking of which a Person can ap-  
“ ply

“ ply to Business with the same Ease  
 “ as before. A Person may know  
 “ how much he ought to eat, by  
 “ finding himself for several Days  
 “ together to return to the same  
 “ Weight after Sleep without any  
 “ Uneasiness. A Body is preserved  
 “ in the same State of Health,  
 “ when it returns to the same  
 “ Weight without any unusual sensible  
 “ Evacuation ; but if it returns  
 “ to the same Weight by a more  
 “ than ordinary Discharge by Urine  
 “ or Stool, the Body begins to  
 “ decline from a State of Health.  
 “ And if a Body returns daily to the  
 “ same Weight without any Change  
 “ made in Perspiration, it will not  
 “ want a Crisis, and be preserved  
 “ in Health.

*Cor. 3.* A grown Person who is  
 constantly to enjoy good Health,  
 requires that the Force of the Heart  
 to

to the Weight of the Body should be nearly the same at all Seasons of the Year. For the Quantity of Blood is nearly as the Capacity of the System of Blood-vessels, and the Capacity of the System of Blood-vessels is as the Force of the Heart; but a grown Person who is constantly to enjoy good Health, at all Times requires a certain determinate Proportion of the Quantity of his Blood to the Weight of his Body; and therefore, he requires a certain determinate Proportion of the Force of his Heart to the Weight of his Body at all Seasons of the Year.

I took the Weights of the Hearts and Bodies of several Animals, and upon comparing the Weight of the Heart with the Weight of the Body, found this Proportion to be greater in Men, Beasts, and Birds, than in Fishes; in small Birds and small Animals

mals than in large ones, in younger Animals of the same Species than in older ones, and in Animals which use much Exercise than in Animals which are inactive.

The Strength, Activity, and Constitution of one and the same human Body in Health, do each of them depend upon the Magnitude of the Proportion of the Force of the Heart to the Weight of the Body. If this Proportion be great, the Body is strong, active, and the Constitution sanguin; and if the Proportion be small, the Body is weak, inactive, and the Constitution fat or phlegmatick.

*Cor. 4.* A grown Person who constantly enjoys good Health, has nearly the same Quantity of Blood at all Seasons of the Year.



*Cor. 5.* The Blood of a grown Person who constantly enjoys good Health, has nearly the same Motion, Tenacity, and Texture at all Seasons of the Year. For since the Force of the Heart and Capacity of the System of Blood-vessels of a grown Person who constantly enjoys good Health, are each nearly the same at all Seasons of the Year; the Motion of the Blood, which is regulated by the Force of the Heart and Capacity of the System of Blood-vessels, is nearly the same at all Seasons: But a given Motion of a given Quantity of Blood produced by a given Force, requires that the Blood should have a given Tenacity, and a given Tenacity requires that the component Parts of the Blood should each have the same Frame, and be in the same Proportion to the rest, that is, that  
the

the Blood should have a given Texture. Therefore, this *Corollary* is true.

### SCHOLIUM.

In this *Proposition* I have proved, that the Weight of the Body, and the Quantity, Tenacity, Texture, and Motion of the Blood of a grown Person who always enjoys good Health, are each of them nearly the same at all Seasons of the Year. And in this *Scholium*, I shall give some Account of the small Changes which may happen in the Weight of the Body, and in the Quantity, Tenacity, Texture, and Motion of the Blood of a grown Person, who may notwithstanding be said to enjoy good Health; and also of the greater Changes in these Particulars which cause Diseases.

First I shall give some Account of the small Changes which may happen in the Weight of the Body, and in the Quantity, Tenacity, Texture, and Motion of the Blood of a grown Person, who may notwithstanding be said to enjoy good Health.

*Sanctorius* informs us, “ That  
“ temperate Bodies are about three  
“ Pounds (that is, near  $2\frac{1}{2}$  *Averdu-*  
“ *pois* Pounds) lighter in Summer  
“ than in Winter; that the Increase  
“ of Weight is made in the Begin-  
“ ning of Autumn, and its Diminu-  
“ tion in the Beginning of Summer;  
“ and that external Cold, by dri-  
“ ving the Heat to the Center, so  
“ far strengthens Nature, as to en-  
“ able it to bear two Pounds of re-  
“ tained perspirable Matter above  
“ its usual Weight.” And in this  
Country I have found, that grown  
Persons who live temperately are ge-  
nerally

nerally a little lighter in Summer than in Winter. The greatest Difference of Weight which a grown Person can undergo without falling into Diseases, I shall call the *healthful Latitude of Weight*.

The healthful Latitude of Weight of grown Bodies is greater in Winter than in Summer, in cold Countries than in hot Countries, and in Persons of strong Fibres than in Persons of weak Fibres. For *Sanc-*  
*torius* found, “ That a Diminution  
 “ of Perspiration, which in Sum-  
 “ mer can cause a malignant Fever,  
 “ can scarcely cause the least Alte-  
 “ ration in Winter; that in a cold  
 “ wholesome Air Perspiration is  
 “ check’d, the Pores are contract-  
 “ ed, but the Fibres are strengthen-  
 “ ed, and the Weight of the re-  
 “ tained perspirable Matter neither  
 “ hurts nor is perceived; and that  
 “ in a foul Air Perspiration is  
 “ check’d,



“ check’d, the Pores are filled up  
“ but not contracted, the Fibres  
“ are relaxed not strengthened, and  
“ the Weight of the retained per-  
“ spirable Matter both hurts and is  
“ perceived :” But from these Ob-  
servations, the Increase of Weight  
which can happen without causing  
Diseases is greater in Winter than in  
Summer ; and consequently, greater  
in cold Countries than in hot Coun-  
tries, and in Persons of strong Fi-  
bres than in Persons of weak Fibres:  
And therefore, the healthful Lati-  
tude of Weight is greater in Win-  
ter than in Summer, in cold Coun-  
tries than in hot Countries, and in  
Persons of strong Fibres than in Per-  
sons of weak Fibres.

Persons of strong Fibres do not  
alter so fast in their Weights by gi-  
ven Changes in the *Nonnaturals*, as  
Persons of weak Fibres; or in other  
Words, the Change of Weight cau-  
fed

fed by a Change of the Temperature of the Air, of Diet, Exercise, or any other of the Nonnaturals, is less in a given Time in Persons of strong Fibres than in Persons of weak Fibres. For by the foregoing Experiments, Changes made in the vibrating Motion of the Fibres by Resistances, and consequently by other Causes (suppose Changes in the Nonnaturals) are less in Persons of strong Fibres than in Persons of weak Fibres : But the vibrating Motion of the Fibres is proportional to the progressive Motion of the Fluids; and the progressive Motion of the Fluids regulates the Weight of the Body, which increases when the Motion of the Fluids lessens, and lessens when that increases: And therefore, the Change of Weight in a given Time caused by given Changes in the Nonnaturals is less, and consequently, slower in Persons of strong Fibres

Fibres than in Persons of weak Fibres.

No Change can happen in the Weight of the Body, but there must at the same Time a Change be made in the Quantity, Tenacity, Texture, and Motion of the Blood. For the Weight of the Body cannot be changed, but by a Change either in the Quantity of Food, or in the Sum of the Discharges; the Body will become heavier when its Food exceeds its Discharges, and lighter when its Discharges exceed its Food; and therefore, the Weight may be increased either by an Increase of the Quantity of Food, or a Diminution of the Sum of the Discharges: But the greatest Part of the Food passes into the Blood, and the two great Discharges, namely Perspiration and Urine, are Humours drawn off from the Blood; whence, no Change can be made in the Quantity

tity of Food or Sum of the Discharges, but there must at the same Time a Change be made in the Quantity of Blood ; if the Food be increased, or the Discharges lessened, the Quantity of Blood will always be increased at the Beginning of the Change, and lessened afterwards if the Change continues till the Body grows fat or phlegmatick ; for Bodies have always less Blood when they are fat or phlegmatick than when they are lean : And therefore, no Change can be made in the Weight of the Body, but at the same time a Change must be made in the Quantity of Blood. A Change in the Quantity of Blood will be attended with a Change in the Capacity of the System of Blood-vessels, and that with a Change of Motion in the Blood ; and a Change in that Motion will be attended with a Change in the Tenacity and Texture ; because the

H h h      Tenacity,



Tenacity, Texture, and Motion of the Blood depend mutually on one another: And therefore, no Change can be made in the Weight of the Body, but there must at the same time a Change be made in the Quantity, Tenacity, Texture, and Motion of the Blood.

The Weight of a Person in Health, the Frequency of the Pulse, and specifick Gravity and Colour of the Urine, are all of them different at different Times of the natural Day. The Body is heavier after eating than before it, heavier after a plentiful Meal than after a spare one, and consequently, heavier after Dinner (which in these Kingdoms is generally the greatest Meal) than at any other Time of the natural Day. The Pulse is quicker after eating than before it, quicker after a plentiful Meal than after a spare one, and consequently, quicker after  
Dinner

Dinner than at any other Time of the natural Day, by *Tab. Exam. 2. Prop. 15.* The mean specifick Gravities of the Urine of a healthful Man aged 56 Years, secerned from the Blood in the Night, Morning, and Afternoon, were 10300, 10292, and 10207; and the mean specifick Gravities of the Urine of 25 healthful Boys, whose mean Age was  $13\frac{1}{2}$  Years, secerned from the Blood in those Times, were 10221, 10220, and 10164. And the Night's Urine is generally of a deeper, and the first Urine after Dinner of a paler Colour, than the Urine made at any other Time of the natural Day. From these Experiments it appears, that an Increase of the Weight of the Body by Food is attended with an Increase of the Quickness of the Pulse, and a Diminution of the specifick Gravity

and of the Intenseness of the Colour of the Urine.

The specifick Gravity of the Night's Urine of a Person in good Health changes, as the Weight of the Body after Sleep is found to have changed; it increases when the Weight of the Body after Sleep is increased, and lessens when that Weight is lessened; as I found by taking my Weight, and the specifick Gravity of my Night's Urine, every Morning for a whole Year; and then taking the Means of the Experiments of every Month. In the Month in which I was lightest, my Weight was 139 *Averdupois* Pounds, and the specifick Gravity of my Urine was 10258; and in the Month in which I was heaviest, my Weight was 142 and  $2\frac{3}{4}$  Ounces, and the specifick Gravity of my Urine was 10321. And in the  
other

other Months, when the Weight of the Body increased or lessened, the specifick Gravity of the Urine increased or lessened. The specifick Gravity of the Night's Urine is less in Children than in grown Bodies, by the last Paragraph; and therefore, in growing Bodies the specifick Gravity of the Urine increases with the Weight of the Body. The specifick Gravity of the Night's Urine lessens again, when Bodies grow old; for the mean specifick Gravity of the Night's Urine of 12 old Men, whose mean Age was 63, was 10218, which is less than the mean specifick Gravity of the Night's Urine of healthful Bodies of a middle Age, which I judge to be about 10300. Now if we suppose, what is generally true, that Bodies shrink in their Dimensions, and lessen in their Weights, when they come to be old; then it will be universally true,



true, that the specifick Gravity of the Night's Urine of healthful Bodies increases or decreases, when there is an Increase or Decrease of the Morning's Weight of the Body after Sleep.

The Quantity of saline and earthy Parts contained in a given Quantity of Blood, may be conjectured from the specifick Gravity of its *Serum*. To form a Rule, whereby to judge of the Quantity of Salt and Earth contained in a given Quantity of Blood, I dissolved different Quantities of several different Salts in a given Quantity of Water; viz. 1, 2, 4, and 6 Drachms of common Salt, Sal-gem, Nitre, Sal-armoniac, volatile Sal-armoniac, Alum, white Vitriol, and Salt of Tartar, in 4 *Troy* Ounces of Water; I took the specifick Gravities of the several Solutions, and found the Excesses of the specifick Gravities of the Solutions

lutions of each Salt above the specifick Gravity of Water, to be nearly as the Quantities of Salt dissolved. The Excesses of the specifick Gravities of the four Solutions of Sal-armoniac above the specifick Gravity of Water, were 104, 208, 398, 585, which were nearly as the Quantities of Salt dissolved. The Excesses of the specifick Gravities of the Solutions of common Salt above the specifick Gravity of Water, were 209, 446, 866, 1154, which likewise were nearly as the Quantities of Salt dissolved. And the same obtained nearly in the Solutions of each of the other Salts. Now if the Salt of the Blood be a Kind of Sal-armoniac, as is generally supposed, if S be put for the Excess of the specifick Gravity of the *Serum* of the Blood above the specifick Gravity of Water, if the Quantity of Salt and Earth contained in any Quantity

Quantity of Blood be ever in a given Proportion to the Quantity of Salt and Earth contained in an equal Quantity of the *Serum* of that Blood, if the Excesses of the specifick Gravities of the Blood and *Serum* in Bodies of a middle Age be 540 and 300, as they may be allow'd to be from Dr. *Jurin's* Experiments, and if the Excesses of the specifick Gravities of the Blood and its *Serum* be as the Sums of the Salt and Earth contained in equal Quantities of those Fluids; then from the foregoing Experiments, .05S will be the Drachms of Salt and Earth contained in a *Troy* Pound of Blood. For Instance, if S be 300, a Pound of Blood will contain 15 Drachms of Salt and Earth.

In order to know how the Blood of Bodies of different Ages is saturated with Salt and Earth, I took the specifick Gravities of the *Serum* of  
the

the Blood of five healthful old Men whose mean Age was 72 Years, and of six healthful Boys whose mean Age was 8 Years, and found their Means to be 10266 and 10277. From these Experiments, the Blood of old Bodies contains something less Salt and Earth than the Blood of young Bodies, and both contain less than the Blood of Bodies of a middle Age, supposing the mean specifick Gravity of the *Serum* of the Blood of Bodies of a middle Age to be 10300. The Quantities of Salt and Earth taken together in a Pound of the Blood of the old Men, the Boys, and Men of a middle Age, are in Drachms 13.3, 13.8, and 15.

The mean Proportions of the *Serum* of the Blood, separated in 24 Hours, to the *Crassamentum* of the six Boys and five old Men, were those of 9187 and 6908 to 10000.



Quantity of Blood be ever in a given Proportion to the Quantity of Salt and Earth contained in an equal Quantity of the *Serum* of that Blood, if the Excesses of the specifick Gravities of the Blood and *Serum* in Bodies of a middle Age be 540 and 300, as they may be allow'd to be from Dr. *Jurin's* Experiments, and if the Excesses of the specifick Gravities of the Blood and its *Serum* be as the Sums of the Salt and Earth contained in equal Quantities of those Fluids; then from the foregoing Experiments, .05 S will be the Drachms of Salt and Earth contained in a *Troy* Pound of Blood. For Instance, if S be 300, a Pound of Blood will contain 15 Drachms of Salt and Earth.

In order to know how the Blood of Bodies of different Ages is saturated with Salt and Earth, I took the specifick Gravities of the *Serum* of  
the

the Blood of five healthful old Men whose mean Age was 72 Years, and of six healthful Boys whose mean Age was 8 Years, and found their Means to be 10266 and 10277. From these Experiments, the Blood of old Bodies contains something less Salt and Earth than the Blood of young Bodies, and both contain less than the Blood of Bodies of a middle Age, supposing the mean specifick Gravity of the *Serum* of the Blood of Bodies of a middle Age to be 10300. The Quantities of Salt and Earth taken together in a Pound of the Blood of the old Men, the Boys, and Men of a middle Age, are in Drachms 13.3, 13.8, and 15.

The mean Proportions of the *Serum* of the Blood, separated in 24 Hours, to the *Crassamentum* of the six Boys and five old Men, were those of 9187 and 6908 to 10000.

And the mean Proportion of the *Serum* to the *Crassamentum* of the Blood of Bodies of a middle Age, has been found to be that of 7143 to 10000. The *Crassamentum* of the Blood of old Bodies is much more tenacious (from a stronger Cohesion of its Parts) than the *Crassamentum* of the Blood of Children, as I have found by Observation.

From the small Difference there is in the Quantities of Salt and Earth in a given Quantity of Blood of old and young Bodies, and the great Difference there is in the Tenacities of their Blood, it is rational to think, that the different Tenacities of the Blood at different Ages depend chiefly on something different from Salt and Earth; which can be no other than Oil, which in itself is a tenacious Liquid, and gives a Tenacity to the Blood; in like manner as it gives a Tenacity to Water when  
it

it is dissolved in it by virtue of Salt ; as we see in a Solution of Soap in Water, and in Mucilages. *See Schol. Prop. 36.*

The Urine of healthful Bodies is higher coloured in the Morning after Sleep, than at any other Time of the natural Day ; it is higher coloured before eating than after it, and the Difference of Colour is greater after a plentiful Meal than after a spare one ; it is higher coloured from much Exercise, Watching, Anger, Fasting, hot Meats, hot Air and hot Weather, than from their Contraries ; it is higher coloured when the Blood abounds more with Bile than when it abounds less with it, as we learn from the *Jaundice* ; it is higher coloured under a greater Degree of Heat in the Blood than under a less ; and it is higher coloured in Men than in Women, and in Persons of a middle Age than in



Children and old Persons. The specifick Gravity of an exceedingly high coloured Urine was 10236, which is less than the specifick Gravity of the Night's Urine of Bodies of a middle Age. Hence, the Colour of the Urine does not depend so much on Salt and Earth as on Oil, and probably depends on the Bile, which contains much Oil in its Composition. For, as I have observed, the Urine is very high coloured in a Jaundice, in which the Blood abounds much with Bile. The Blood abounds more with Bile, and the Urine is higher coloured, when the Degree of Heat in the Blood is greater than when it is less. And farther, by mixing different Quantities of Gall with plain Water, we may produce the several Colours which are ordinarily observed in Urine. One Part of the Gall of an Ox, mix'd with 15 or 16 Parts of Water, produced

duced the Colour of the Night's Urine of healthful Men of a middle Age. And the Colour of the Urine is sometimes so intense, as to require one Part of Gall to two of Water to produce it.

Secondly, I shall give some Account of the greater Changes in the Weight of the Body, and in the Quantity, Tenacity, Texture, and Motion of the Blood, which cause Diseases.

The Change of Weight which causes Diseases, commonly exceeds the healthful Latitude of Weight; and consequently, is greater in Winter than in Summer, in cold Countries than in hot Countries, and in Persons of strong Fibres than in Persons of weak Fibres. The Weight of the Body is usually increased at the Beginning of Fevers, and the most general Causes of Fevers are Cold, an Increase of Food,  
or

or a Diminution of Exercise; all which are fitted to increase the Weight of the Body. But what the particular Increase of Weight is at the Beginning of different Fevers, in Persons of different Ages, Climates, and Constitutions, is not yet known for want of Experiments.

The Blood abounds more with Salt, Earth, and Oil, and is more tenacious at the Beginning of Fevers, than in a State of Health; as may be proved from the Experiments of *Tabor* and *Langrish*.

From the Experiments of *Tabor*, the specifick Gravities of feverish *Serum* are to the specifick Gravity of healthful *Serum*, as the Numbers 10363, 10381, 10399, or 10417 to 10308; or as the Numbers 10355, 10372, 10391, or 10409 to 10300, supposing 10300 to be the specifick Gravity of healthful *Serum* of the Blood of Bodies of

a middle Age. From these specifick Gravities, the Drachms of Salt and Earth taken together contained in a *Troy* Pound of feverish and healthful Blood will, by the foregoing Rule, be nearly  $17\frac{3}{4}$ ,  $18\frac{1}{2}$ ,  $19\frac{1}{2}$ , or  $20\frac{1}{2}$  and 15. From the Experiments I made on myself I gather, that the specifick Weight of the *Serum* may increase from 10300 to 10321 without causing Diseases; and therefore, the Quantity of Salt and Earth in a Pound of Blood of Bodies of a middle Age, may increase from 15 to 16 Drachms without causing Diseases. The farther Increase from 16 till you come to  $17\frac{3}{4}$ , may only cause common Colds, or other slight Diseases, but not be sufficient to cause a Fever, at least not one of any great Consequence. *Tabor* gives an Account of a Fever of the pleuritick Kind, which was mortal to many of the common People of  
*England,*



*England*, in which the specifick Gravity of the *Serum* was ordinarily between 10372 and 10391. The mean specifick Gravity of the *Serum* of the Blood of seven Men in Fevers in this Kingdom, who all escaped, was 10358 : And the mean specifick Gravity of the *Serum* of one who died, was 10369 ; at the Beginning of the Fever the specifick Gravity of his Urine, taken at a Medium from the 7th Day to the 11th, was 10295 ; it then sunk to 10211, and continued in that State till he died, which was on the 12th.

From *Tabor's* Experiments, the Proportion of the *Crassamentum* of healthful Blood to the *Serum* separated from it in 24 Hours, is that of 7 to 5, or of 1400 to 1000. And the Proportions of the *Coagulum* of a given Quantity of *Serum* to the Part evaporated by a gentle Heat in

24 Hours, in the mortal Fever before mentioned, in ordinary Fevers, and in Health, were those of 3000, 2333, and 1500 to 1000.

From the Experiments of *Langrish*, the mean Proportions of the *Crassamentum* of the Blood to the *Serum* separated in 24 Hours, in continual, quotidian, tertian, and quartan Fevers, were those of 3992, 3614, 3154, and 2424 to 1000; the mean Degrees of Cohesion, measured by a Weight just sufficient to separate the Parts of the *Crassamentum* of the Blood, in the said Fevers and in Health were, taking in the Weight of the Tube, as the Numbers 1603, 1275, 1152, 898, and 621; the Quantities of Salt, Oil, and Earth, obtained by Distillation from a given Quantity of Blood, were all greater in feverish Blood than in healthful Blood; and the Differences were much greater in

K k k the

the Quantities of Salt and Oil, than in the Quantities of Earth ; and the Urine which in the *Crisis* of a Fever deposited a large Sediment, contained a little less Water and Earth, but about three times more Salt, and near eight times more Oil, than were contained in an equal Quantity of healthful Urine.

From all these Experiments it appears, that the Blood abounds more with Salt, Earth, and Oil, and is more tenacious at the Beginning of Fevers, than in Health. Hence to cause a Fever, the Discharges of the Body must be more watry, or contain fewer saline, earthy, and oily Parts, for some little Time before the Fever commences, than they do in a State of Health ; and therefore, the Things which cause Fevers must be such as render the Discharges more watry : But the Discharges are render'd more watry by taking Cold,

an Intermission of Exercise, and an Increase of the Quantity of Food : And therefore, taking Cold, a sudden Increase of the Food, and a sudden Intermission of Exercise, are the Causes of Fevers ; as they are also found to be by Observation.



## PROPOSITION XLV.

**I***F the Force which moves the whole System of Fluids in an animal Body be given ; an Increase or Diminution of the Motion of the Fluids in any one Part of the System, will be attended with an equal Diminution or Increase of their Motion in other Parts of it ; and the Diminution or Increase of Motion in the other Parts will be greater or lesser, as they are nearer to or farther from that Part.*



For the moving Force of the whole System of Fluids of an animal Body being given by Supposition, the Motion of the whole System generated by that Force in a given Time will be given : But a given Motion of the whole System necessarily requires, that an Increase or Diminution of Motion in any one Part of the System should be attended with an equal Diminution or Increase of Motion in the other Parts of it ; otherwise, the Motion of the whole System will not be given ; and the Diminution or Increase of Motion in the other Parts will be greater or lesser, as they are nearer to or farther from that Part, by *Prop. 7. 19* : And therefore, the *Proposition* is true.

*Cor.* If this *Proposition* be true, an Increase or Diminution of any  
one

one Discharge, or of the Motion of the Blood in any one Part of a human Body, will be attended with an equal Diminution or Increase of the other Discharges, or of the Motion of the Blood in the other Parts of the Body; and the Diminution or Increase of the other Discharges, or of the Motion of the Blood in the other Parts, will be greater or lesser, as the Discharges or Parts are nearer to or farther from that Discharge or Part.

We find by Observation, that in a *Diarrhœa*, Persons perspire little and make little Urine; that in a *Diabetes*, Persons perspire little and are costive; that Persons who *sweat* much, commonly discharge but little by Urine and Stool; that in a *Catarrh*, the Discharges by Perspiration, Urine, and Stool are commonly all lessened; that in a confirmed *Phthisis*, a large *Diarrhœa*  
lessens

lessens the Discharges by Sweat and Spitting, great *Sweats* lessen the Discharges by Stool and Spitting, and a great Discharge by *Spitting* lessens the Discharges by Sweat and Stool; that in the *Small Pox* and other *eruptive Fevers*, in which the Blood and Humours flow plentifully to the Skin, Persons are generally costive and make but little Urine; that in other *Fevers* an Increase of the Symptoms in one Part is generally attended with a Diminution of the Symptoms in other Parts; and that Perspiration compared with Urine, and consequently the Motion of the Blood at the Surface of the Body compared with its Motion in the inward Parts, is greater in Summer than in Winter, in hot Countries than in cold Countries. These Observations shew, that an Increase or Diminution of one Discharge, or of the Motion of the Blood in one  
Part

Part of the Body, is attended with a Diminution or Increase of other Discharges, or of the Motion of the Blood in other Parts of the Body.

*Hippocrates* has informed us,  
 “ That Gripes, a Weight in the  
 “ Knees, and Pain in the Loins,  
 “ require Purging; that a violent  
 “ Disorder and Pain in the Head  
 “ cease on the breaking forth of  
 “ Pus, Water, or Blood, at the  
 “ Nose, Mouth, or Ears; that a  
 “ loathing of Food, Heart-burn,  
 “ Vertigo, and Bitterness in the  
 “ Mouth, in a Person who has not  
 “ a Fever, require vomiting; that  
 “ in Summer we ought rather to  
 “ vomit, and in Winter to purge;  
 “ that for Pains which require vo-  
 “ miting or purging, we ought to  
 “ vomit when the Pains are above  
 “ the Diaphragm, and to purge  
 “ when they are below it; that Hu-  
 “ mours which ought to be moved  
 “ and



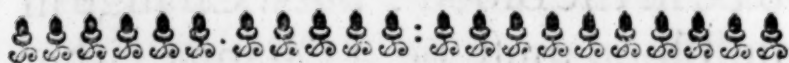
“ and discharged, must be moved  
“ towards and discharged by those  
“ Places to which they most tend,  
“ provided the Places be conveni-  
“ ent.” By these Observations,  
when Evacuations are necessary to  
empty particular Parts, they ought  
to be made in convenient Places  
nearest to those Parts. Hence it is,  
that in an Apoplexy caused by too  
great a Quantity of Blood in the  
Brain, more speedy Relief is given  
by drawing Blood from the Neck,  
than from more remote Parts of the  
Body; and that in Inflammations,  
more speedy Relief is given by  
drawing Blood from Vessels which  
lie near them, than from Vessels ly-  
ing at a Distance.

But though Parts loaded with  
Blood and Humours are more emp-  
tied by near Evacuations, than by di-  
stant ones of equal Quantities; yet,  
the Depletion by an Evacuation  
from

from a near Part is often not so lasting, and consequently, not so serviceable, as the Depletion by an Evacuation from a remote Part. For a near Evacuation gives a Tendency to the Blood and Humours towards the loaded Parts; which Tendency continuing after the Evacuation is over, makes the emptied Parts soon to fill again, unless the Discharge be very great: But an Evacuation from a remote Part gives a Tendency to the Blood and Humours towards that Part; which Tendency continuing after the Evacuation is over, causes a more plentiful Flow of Blood and Humours to that Part, and consequently, a more sparing Flow of them to the loaded Parts: And therefore, the Depletion, and consequently, the Benefit arising from it, will not be so lasting from an Evacuation made in a near Part, as from an Evacuation made in a remote Part. Accordingly, *Tral-*

*lian* in the Cure of a *Hæmorrhage* from a Rupture of the Vessels in the upper Parts, found much more Benefit from bleeding in the Ankle than in the Arm; and expressly says, that a Sollicitation of the Humours to the remoter Parts makes a more lasting Revulsion. And it has been found by Experience, that drawing 8 or 9 Ounces of Blood from the *Hæmorrhoidal* Veins by Leeches, after bleeding in the Arm, is more prevalent in spitting or vomiting of Blood, or bleeding at the Nose, than repeated Bleedings from the upper Parts: And that Pains in the upper Parts, particularly the Head and Side, are often more relieved by bleeding in the Foot than by bleeding in the Arm. So then to make a large and speedy Depletion of the Vessels, the Evacuation must be made as near the loaded Part as is possible; but to make the Benefit of such Depletion

tion lasting, Recourse must be had to Evacuations from the remotest Parts.



PROPOSITION XLVI. Problem VI.

**T**HE Causes, Nature, and Symptoms of Fevers being known; thence to determine the Methods of Cure.

The Causes of Fevers are either remote or immediate.

The common and ordinary remote Causes of Fevers, are Cold, Excesses in Eating and Drinking, an Excess or Intermission of Exercise of Body or Mind, and a Suppression of some Discharge to which the Body has been accustomed; all which, when great and sudden, are very apt to occasion Fevers.

The immediate Cause of Fevers, is the Change which is made in the Tenacity and Texture of the Blood



by the remote Causes. For all allow the immediate Cause of Fevers to be in the Blood : But a Change in the Blood must be a Change either in its Tenacity or Texture: And therefore, the immediate Cause of Fevers is the Change which is made in the Tenacity and Texture of the Blood by the remote Causes.

The *Tenacity* of the Blood, as far as yet appears from Experiments, is greater at the Beginning of Fevers than in Health, by *Schol. Prop. 44.* The same Thing may likewise be gathered from the Chilness and Coldness with which Fevers are introduced, and also from the Effects produced in the Blood by the remote Causes. For, cold Air, and an Intermission of Exercise of Body or Mind, will occasion a Diminution of the Heat of the Blood; and a Diminution of the Heat of the Blood will be attended with an Increase

crease of its Tenacity, by *Prop.* 41 ; an Excess of Exercise, by wasting the watry Part of the Blood, will leave the Blood more than ordinarily tenacious when the Body comes to cool ; Excesses in eating and drinking will necessarily increase the Tenacity of the Blood if the Food be of a strengthening Nature, as it commonly is when Fevers arise from Excesses in Diet ; for of all Kinds of Food, Flesh Meats and strong Liquors are aptest to produce Fevers ; and the same Effect will follow from the Suppression of a Discharge to which the Body has been accustomed, if the Suppression be caused, as it usually is, by Things of a strengthening Nature, such as Cold, Astringents, and the like.

The Blood, as to its *Texture*, abounds more with saline, earthy, and oily Parts, or, in other Words, its Quantity of these Parts in Proportion

portion to its Quantity of Water, is greater at the Beginning of Fevers than in Health, by *Schol. Prop. 44.* And this likewise may be gathered from the Effects of the remote Causes of Fevers on the Discharges. Perspiration and Urine (the two great Discharges of the Body) are more watry, or abound less with saline, earthy, and oily Parts, when a Body is cold than when it is hot; and they are more watry under Excesses in eating and drinking than under a temperate Diet, from the Urine's being more watry after a full Meal than after a spare Meal, by *Schol. Prop. 44*; and from these Discharges being rendered more than ordinarily watry by Cold, and an Excess in eating and drinking, we may infer, that these two remote Causes of Fevers will overstock the Blood with saline, earthy, and oily Parts; for the fewer of these Parts the Discharges

charges contain, the more must the Blood be saturated with them. An Intermission of Exercise, by lessening the Heat of the Blood, makes the Discharges more watry; and consequently overstocks the Blood with saline, earthy, and oily Parts. On the other Hand, an Excess of Exercise, by carrying off large Quantities of the watry Part of the Blood, will leave a more than ordinary Proportion of Salt, Earth, and Oil in the Remainder. And a sudden Suppression of a Discharge to which the Body has been accustomed, must have the same Effect in overstocking the Blood with those Parts, if the Matter of the Discharge abound with them. So that the common and ordinary remote Causes of Fevers do all of them foul the Blood, by making it to abound more with Salt, Earth, and Oil, than it does in Health. Hence Fevers may differ



fer in their Natures, from Differences in the Tenacity and Foulness of the Blood.

The Weight of the Body is usually increased at the Beginning of Fevers ; and the Increase of Weight is greater in Winter than in Summer, in cold Countries than in hot Countries, and in Persons of strong Fibres than in Persons of weak Fibres, by *Schol. Prop. 44.* The Increase of Weight in any Time, is always equal to the Excess of the Food above the Discharges in that Time ; and therefore, the Increase of Weight at the Beginning of Fevers arises either from an Increase of the Food, or a Diminution of the Discharges, or from both. The Discharges are lessened by sudden Cold, a sudden Intermission of Exercise, or a sudden Suppression of an Evacuation to which the Body has been accustomed ; and therefore, all the common  
remote

remote Causes of Fevers, excepting Excess of Exercise, are fitted to increase the Weight of the Body. If the Increase of Weight arise from an Increase of the Quantity of Fluids, as we may allow it to do from the remote Causes, it must arise from an Increase of the Quantity of Blood, or an Increase of the Quantity of Humours separated from the Blood, or from both. It probably arises more from an Increase of Blood than of Humours, in sanguin Bodies; and more from an Increase of Humours than of Blood, in Bodies which are fat or phlegmatick.

When the Blood by the remote Causes is rendered so tenacious and foul, as to require a Depuration; the Body grows chill and cold, and frequently shudders, as healthful Bodies do when they are greatly chilled by intensely cold Air. During this State of the Body, the Pulse is very

M m m *low*

*low* and *quick*; and if a Vein be opened, the Blood flows out either by Drops, or so slow and cold as to coagulate as it falls. After the Coldness and Want of Motion in the Blood, a preternatural State as to Heat and Motion succeeds in it, which I call a *Fever*. If the Heat of the Blood be greater, and the Pulse be greater and quicker, than they are in a natural and healthful State, I shall call the Fever a *high Fever*; and if the Heat of the Blood be less, and the Pulse less and quicker, than they are in a healthful State, I shall call the Fever a *low Fever*.

A Fever is the great Instrument with which Nature depurates foul Blood, and reduces it to a natural State. This appears plainly from hence, that nothing makes tenacious Liquids, and consequently tenacious Blood, so fluid as Heat; that nothing removes Obstructions in  
the

the Blood-vessels so soon and so effectually, as an increased Heat and Motion of the Blood; and that those Fevers terminate soonest by a *Crisis*, in which the Heat and Motion of the Blood are greatest; and those latest in which the Heat and Motion of the Blood are least: Or in other Words, that the *highest Fevers* terminate soonest by a *Crisis*, and the *lowest Fevers* latest.

When the Matter which fouls the Blood, that is the febrile Matter, is rightly concocted by the Fever, Nature separates it from the Blood, and discharges it out of the Body in a *salutary Crisis*. A *salutary Crisis* in Fevers is made by *Sweats*, *Urine*, *Hæmorrhages*, *Fluxes of the Belly*, and sometimes by *Spitting*. High Fevers for the most part end by Sweats; and and in the End of all Fevers, by whatever Evacuation they terminate, the Recovery to perfect Health



is by a natural Sweat. When the *Crisis* is made by *Sweat*, the Sweat is thin, warm, and profuse; and the sick Person is freed from the Fever by it: When it is made by *Urine*, the Urine is made first in a small Quantity, and of a Straw Colour; but soon in a greater Quantity, with many Contents falling to the Bottom or swimming in it: When made by *Hæmorrhages*, the Flux of Blood may be great in Quantity, but is commonly of a short Duration: When by a *Flux of the Belly*, the Flux is generally without Gripes, and commonly goes off in a Sweat: And when by *Spitting*, the Discharge is thin, *Aphthæ* arise which soon heal, and a Concoction appears in the Urine at the same Time. In the *Small Pox*, *Measles*, *Scarlet* and *Erysipelatous Fevers*, the Blood is depurated by *Eruptions* and *Efflorescences* in the Skin; in *Pleurisies*, often by *Expectoration*;

ration; and in the *Plague* and *Pestilential Fevers*, frequently by *Swellings in the Glands*.

The Symptoms attending Fevers, and what those Symptoms portend, are best known from the *Aphorisms*, *Epidemicks*, and *Prognosticks* of *Hippocrates*, and a late learned Treatise upon them by a Physician in this Kingdom; to which I refer.

From this Account of Fevers, I now proceed to determine the *Methods of Cure*. From a Fever's being the great Instrument Nature uses to depurate foul Blood, it is evident, that what is called the Cure of a Fever, is only such a Regulation of it as makes it best answer that End. A just Regulation of a Fever consists in making such Evacuations, and directing such Diet and Medicines, as shall make the Fever depurate the Blood in the most perfect Manner. In appointing these Things, Regard  
must

must be had to the Age, and Habit of the Body; to the Nature, Symptoms, and Time of the Fever; and to the Distance of the *Crisis*.

From the *Increase of Weight*, we may infer the Usefulness of Evacuations in the Beginning of Fevers. The Body is emptied various Ways, namely, by *Fasting, Bleeding, Purging, Vomiting, Sweating, and Blistering*; all which I shall consider particularly, and shew which of them, under given Circumstances, will be most proper to lessen the increased Weight in the Beginning of Fevers.

*Fasting* lessens the Weight of the Body, not by causing any Evacuation, but from a Continuance of the Discharges during the Time of the Fast. I have known a Man in Health to lose near 4 Pounds of his Weight in 24 Hours, by wholly abstaining from Meat and Drink during that Time. From the Continuance of the

the Discharges during the Time of the Fast, we may gather that Fasting increases the Proportion of the *red Part* of the Blood to the *Serum*. Accordingly, this Proportion has been found very great in Persons who have died with Hunger. *Hippocrates* says, “ that Fasting is to “ be prescribed to Bodies which “ have moist Flesh, for Fasting dries “ Bodies.” Bodies in Dropsies have sometimes been freed from their Load of Water, by wholly abstaining from Drink and living only upon dry Meat. Hence, Fasting is useful in the Beginning of Fevers in which the Increase of Weight is more from Humours than from Blood; and consequently, is more useful in phlegmatick Bodies, than in sanguin Bodies; in Winter, than in Summer; and in cold Countries, than in hot Countries. But tho’ Fasting empties the Body, yet it does not appear,



appear, that it alters the Proportions of the Quantities and Motions of the Fluids through its several Parts : And therefore, when the Quantities and Motions of the Fluids are too great in some Parts, and too little in others ; or, when they are more increased in some Parts than in others, as they frequently are in Fevers, we cannot hope to correct those Irregularities by *Fasting* ; but must have recourse to some of the following Evacuations.

*Bleeding* lessens the Weight of the Body, by lessening the Quantity of Blood ; and therefore, is useful in the Beginning of Fevers in which the Increase of Weight is more from Blood than from Humours ; as we may suppose it to be in sanguin Bodies, that is, in Bodies which have much Blood in Proportion to their Weights : But Bodies have more Blood when they are lean than when  
they

they are fat ; and Bodies are generally leaner in Summer than in Winter, and in hot Countries than in cold Countries : And therefore, bleeding in the Beginning of Fevers is generally more useful in lean Bodies, in Summer, and hot Countries, than in fat Bodies, in Winter, and cold Countries. Accordingly, bleeding is more used, and with better Success, in *Italy, France,* and *Spain*, than in these and other Northern Kingdoms. Bleeding is useful in all Seasons and in all Climates, in the Beginning of Fevers attended with Inflammations ; and much more so, when the Pulse is *hard*, as it is in Fevers attended with an Inflammation of the *Pleura*, and other membranous Parts. In these Fevers, when the Removal of the Inflammation is committed wholly to Bleeding, without any other Evacuation, large Quantities of Blood

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must

must be drawn ; and it must be taken, first from a convenient Part which lies nearest to the inflamed Part ; and afterwards from a convenient Part which lies at the greatest Distance from it, by *Cor. Prop. 45*. Thus we find that in a true *Pleurisy*, or an *Inflammation* of the *Membranes of the Brain*, bleeding to the Quantity of 9 or 10 Ounces from the Foot, after bleeding largely from the Arm or Neck, gives greater Ease than repeated Bleedings from the upper Parts.

*Purging* lessens the Weight of the Body, by lessening the Quantity of Humours. The mean Loss of Weight of several grown Bodies, caused by a purging Medicine composed of a Drachm of *Jalap* and 10 Grains of *Calomel*, was about  $2\frac{3}{4}$  *Averdupois* Pounds ; and the mean Quantity of Liquor, drunk during the Time of purging, was about  
double

double the Loss of Weight. And the Loss of Weight caused by weaker Purges and *Clysters* is proportionably less. Farther, Purging draws the Blood and Humours from the upper and outward Parts of the Body towards the lower and inward Parts, by *Prop.* 19. 45, and the following Observations. *Hippocrates* observed, “ that it is good for a  
 “ Person who has an Inflammation  
 “ in his Eyes, to be seized with a  
 “ Flux of the Belly; that when a  
 “ *Diarrhæa* happens to a Woman  
 “ with Child, she is in Danger of  
 “ miscarrying; and that a Deafness  
 “ in Fevers is carried off by bleed-  
 “ ing at the Nose, or spontaneous  
 “ Purging.” And we find by Experience, that, after bleeding when necessary, moderately strong Purges (composed of *Jalap* or *Pulvis Warwickensis* and *Calomel*) are very effectual in removing Pains and Inflam-



mations in the *Eyes, Side, Head* and *Throat*, and in procuring the *Catamenia*; and that Persons under a strong *Diarrhæa*, or a *Diabetes*, discharge but little by Perspiration: All which abundantly shew that Purging draws the Blood and Humours from the upper and outward Parts of the Body to the lower and inward Parts. *Hippocrates* likewise observed, “ that a strong *Diarrhæa* “ coming on a *Leucophlegmatia*, “ cures it.” Whence I infer, that Purging is useful in the Beginning of Fevers, in which the Increase of Weight is more from Humours than from Blood; which is frequently the Case in cachectick Bodies, in Winter, and in cold Countries. Purges, during the Time of their Operation, empty the lower Parts more than the upper Parts: But after the Operation is over, the lower Parts fill again; whence the Depletion

tion of the upper Parts becomes greater and more lasting, by *Cor. Prop. 45.*

*Vomiting* lessens the Weight of the Body, partly by unloading the Stomach and its neighbouring Parts, and partly by increasing Perspiration; and therefore, is useful in the Beginning of Fevers, in which the Stomach is foul, and the neighbouring Parts are loaded with Humours from a Diminution of Perspiration by Cold or other Causes. Farther, Vomiting turns the Blood and Humours from the lower and inward Parts of the Body to the upward and outward Parts; as may be gathered from the following Observations. *Hippocrates* has observed, “ that a  
“ spontaneous Vomiting coming  
“ on a long Flux of the Belly, cures  
“ it.” And we find by Experience, that Vomiting is of great Service in checking a *Dysentery*, an immoderate

rate Flux of the *Catamenia*, a Flux of Blood from the *Anus*, an *Hæmoptoe*, a *Diarrhæa*, a *Fluor albus*; and a *Gleet*; and that the Face and Eyes are commonly very red, and the Body frequently sweats, during the Action of Vomiting: All which plainly shew, that Vomiting turns the Blood and Humours from the lower and inward Parts of the Body to the upper and outward Parts. Hence, the Effects of Vomiting and Purging, with regard to the Changes they make in the Motions of the Fluids in different Parts of the Body, are contrary to each other; Vomiting increases and Purging lessens their Motion in the upper and outward Parts, and Vomiting lessens and Purging increases their Motion in the lower and inward Parts. Repeated Purging brings down the *Catamenia*, by increasing the Motion of the Blood through the *Womb*;

*Womb*; and Vomiting after other Evacuations, namely, Bleeding in sanguin Bodies and Purging in cachectick Bodies, contributes much to remove the Inflammation in Pleurifies, by increasing the Motion of the Blood through the inflamed Part. It may be objected, that Vomiting in an *Hæmoptoe* will increase the Spitting of Blood; but this Objection is groundless: For I have rarely observed any Blood to be discharged during the Operation of a Vomit, and never any remarkable Quantity. Nor is there any Reason to apprehend, that Vomiting in an immoderate Flux of the *Catamenia* will increase it; since the Vomiting of Women with Child does not bring on that Discharge. Lastly, Vomits, by the strong Motion of the Muscles which attends their Operation, attenuate tenacious Blood and increase its Motion;



tion; and are therefore useful on those Accounts, after other Evacuations, in the Beginning of Fevers attended with Inflammations and a small Motion of the Blood: Accordingly, I have frequently observed the Pulse to be raised by Vomits in low Fevers from a tenacious Blood.

*Sweating* lessens the Weight of the Body considerably. I have known a grown Person to have lost two Pounds in half an Hour, by sweating in a Chair contrived for that Purpose. This Evacuation is frequently of great Use in the Beginning of *Colds*, and slight Fevers; and also in high inflammatory Fevers in young Bodies, which may often be taken off in a little Time, by keeping them in a constant gentle Sweat in Bed with the testaceous Powders given in cold Water. Grown Bodies may take a Drachm of the Powders in three or four Ounces of cold Water

Water every third or fourth Hour, and Children five or six Years old may take half the Quantity of the Powders in half the Quantity of Water. It is to be observed, that Persons thus treated ought to be bled and vomited before they begin the Use of the Powders. If this Method be used at the Beginning, it generally takes off the Fever with all its Symptoms in less than two natural Days; but seldom in less than three or four, if it be not used till the seventh or eighth Day of the Disease. Grown Bodies thus treated often begin to spit a Day or two after they begin the Use of the Powders, and continue spitting for some Days after the Fever has left them. This is a natural Method of treating high inflammatory Fevers, in which the Blood is rendered tenacious by Cold and too great a Quantity of the Acid of the Air. For the Heat of the

O o o                      Body

Body in Sweating will take off the preternatural Tenacity of the Blood, as far as it is caused by Cold; and the testaceous Powders, from their being of an alcalious Nature, will be proper to take it off as far as it depends on the Acid of the Air; and Sweating, both by emptying the Body, and turning the Humours to the Skin, will greatly contribute to take off Inflammations in the inward Parts. Sweating with acidulated Drinks, taken warm, and Cordials, is a proper Evacuation in the Beginning of Fevers in which the Salts of the Blood are rendered too volatile by Heat or Putrefaction; as we may suppose them to be in Child-bed, pestilential, and other putrid Fevers. For Sweating will carry off Part of the volatile Salts, and Acids will be proper to correct the Remainder. After a Vomit, I have known gentle and frequently repeated

ed Sweats, excited in Bed by small Quantities of Liquors taken hot, of great Use in the Beginning of low Fevers attended with frequent and irregular Successions of Cold and Heat for three or four of the first Days. These Fevers frequently happen in this Kingdom to Men of a middle Age, and by being neglected in the Beginning often prove mortal. Sweating, as it attenuates the Fluids and turns their Course to the Skin, and as it relaxes and weakens the Fibres, will be more useful in the Beginning of Fevers in Winter than in Summer, in cold Countries than in hot Countries, and in Persons of strong Fibres than in Persons of weak Fibres.

*Blistering* lessens the Weight of the Body but little, and therefore, is but of little Use to take off the Increase of Weight in the Beginning of Fevers. In the Progress of

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Fevers,



Fevers, Blisters sometimes do Good, and sometimes Hurt. In low Fevers in which the Blood is tenacious, Blisters often do Good by increasing the Fever, and lessening the Tenacity of the Blood; which Effects they produce by the Pain, Heat, and Inflammation which they commonly raise in the Part to which they are apply'd, and by the volatile Salts which they communicate to the Blood. In this Case, they must be repeated as often as their Effect in the Blood ceases, till within a very little Time of the *Crisis*. In low Fevers in which the Blood is dissolved, as we may reasonably suppose it to be in Fevers attended with *purple Spots* and *Hæmorrhages*, Blisters do Hurt by farther increasing the Dissolution and Acrimony of the Blood. Blisters frequently hurt in high Fevers, and sometimes cause Convulsions and Death, unless they be apply'd

ply'd at a considerable Distance from the Head, and Opiats be given at the same Time. And they oftener hurt in high Fevers, when apply'd at or very near the Time of the *Crisis*, than when apply'd at any other Time of the Fever. In high eruptive Fevers, particularly the Small-Pox, Blistering along with other Evacuations, just before or after the Appearance of the Eruption, sometimes checks or strikes in the Eruption; and instead thereof, throws out purple Spots, causes Convulsions and Death. And in other high Fevers, a Separation in the Urine at a proper Time (which is a Sign of Concoction and an approaching *Crisis*) often goes off on the Application of Blisters, and does not appear again in several Days, and sometimes not at all. This is agreeable to the Doctrine of *Hippocrates*, who directs, “ In the Crisis of Fevers  
“ and

“ and after a perfect *Crisis*, not to  
“ move or make any Change either  
“ by purging Medicines or other  
“ Irritations, but to leave all to Na-  
“ ture.” As Fevers are generally  
less ardent, that is, lower, so Bli-  
sters are generally more useful, in  
Winter and cold Countries, than in  
Summer and hot Countries. Blisters  
apply’d to the Back, after Persons  
have begun to spit in Inflammations  
of the Lungs and Pleura, I have  
known to do hurt by quieting the  
Cough, and stopping the Spitting;  
and thereby, increasing the Difficulty  
of Breathing and Inflammation.  
Blisters apply’d to the Back in Fe-  
vers often ease the Head more during  
the Time of their rising, than Bli-  
sters apply’d to the Thighs or Legs;  
but the Ease given to the Head is  
often more lasting from Blisters ap-  
ply’d to the Thighs or Legs, than  
from Blisters apply’d to the Back.  
I have

I have known Blisters to quiet a Vomiting, and lessen a *Diarrhæa* in Fevers; and they are particularly serviceable in the Convulsions of low Fevers attended with much *pale Urine*, commonly called *nervous Fevers*. *Hippocrates* observed, “ that  
 “ all Abscesses of the Legs are good  
 “ in Inflammations of the Lungs;  
 “ and that of two Pains which hap-  
 “ pen together, but not in the same  
 “ Part, the greater obscures the  
 “ lesser.” Hence, the Relief may be greater, but not not so lasting, from a Blister applied near to a distressed Part, than from a Blister applied at a great Distance from it.

To what has been said concerning Evacuations, may be added, that when such Evacuations are made as ought to be made, Persons bear them easily, and are relieved by them. This is the Rule whereby *Hippocrates* judged of the Usefulness



ness or Hurtfulness of Evacuations, whether made by Nature or Art; and it ought ever to be carefully attended to, not only in Fevers, but in all other Diseases. We may farther add, that Evacuations ought generally to be made in the Beginning of Fevers, and to be finished within three or four of the first Days: Excepting, that in Fevers in which the Head is much engaged, Clysters may be used, to draw the Humours gently from the Head by giving them a Tendency to the lower Parts, till Signs of Concoction appear in the Urine; and that in high Fevers, attended with an Inflammation of some principal Part, Evacuations may be used, to prevent Suppuration, till the Inflammation is either totally removed, or greatly abated. This may suffice concerning Evacuations in Fevers. I now proceed to consider the Diet and Medicines, which

which are proper in these Diseases.

The Diet and Medicines must be such, as are fit to regulate the preternatural Heat and Motion of the Blood, that is, the Fever; so as that it may perfectly depurate the Blood, and restore it to a healthful State. The Diet must be cooling, if the Fever be high; and warming, if the Fever be low. Diet is cooling, either as it is of a cooling Nature, or as it is taken actually cold; and it is warming, as it is of a warming Nature, or as it is taken actually hot. Gruels, Panada, plain Water, Barley-water, Ptisan, Small-beer, and Whey, made with small White-Wine, Cyder, Juice of Lemons, Juice of Oranges, Vinegar, or Buttermilk, are all of a cooling Nature; and Broths of Flesh, Ale, Wine, and other strong fermented Liquors, and Whey made with strong fermented

P p p                      Liquors,

Liquors, are all of a warming Nature. Any of the Things here mentioned which are of a cooling Nature, may become warming by being taken hot; and any of those which are of a warming Nature, may lose much of that Quality by being taken cold. For in low Fevers, plain Gruels and Barley-water taken hot increase the Heat and Motion of the Blood, that is, heighten the Fever more, than many Liquids of a warming Nature taken cold. Drinks become more cooling by being impregnated with *Acids*, or with *Nitre*; both of which are of a cooling Nature, and may be given in high Fevers till Signs of Concoction appear in the Urine; but no longer, lest by their cooling Quality they should hinder a perfect Concoction of the febrile Matter, and thereby retard, if not intirely prevent the *Crisis*. *Acids* and *Nitre* ought not

to be given in low Fevers in which the Blood is tenacious : For, by their cooling and diuretick Quality, they will make the Fever still lower, and the Blood still more tenacious ; the Consequence of which will be, that there will be no *Crisis* during their Use ; and the Want of a *Crisis*, and of a thorough Extermination of the febrile Matter by it, will make the Recovery to Health at best very slow and uncertain. In such Fevers, volatile alcalious Salts and Spirits must be given to thin the Blood, and all Liquids must be taken hot to rarefy it and increase its Motion. But tho' Acids are hurtful in Fevers which are low from too great a Tenacity in the Blood, yet they are very useful in low Fevers in which the Blood is dissolved and its Salts are rendered volatile, by Putrefaction ; in which Fevers, all Liquids must be taken warm, in order to raise and keep up a gentle



Sweat. In these Fevers, Cordials composed of ardent Spirits and Acids must be used, to give Tenacity to the Blood and Strength to the Fibres.

If we suppose the Demand of Nature to be a just Measure of the Quality and Quantity of the Nourishment which are proper in Fevers, we may from the Demand collect the following Rules concerning Diet; namely, All solid Food ought to be rejected, and liquid Food only admitted in Fevers; because, in all Fevers there is an intire Aversion to solid Food, and a Demand only for Liquids. Cooling acidulated Drinks ought to be taken plentifully in high Fevers; because, there is a great Demand for such Drinks in those Fevers. Little Drink ought to be taken in low Fevers from a tenacious Blood; because, there is but little Demand for Drink in those Fevers; and what is taken,

ken, must be taken hot to increase the Fever. Nothing ought to be taken, when there is no Demand ; as there seldom is in the very Beginning of Fevers, and in the Beginning of their Exacerbations and Paroxysms, in which the Body is cold, and the Motion of the Blood very low. And Drink ought to be taken plentifully in all Fevers in which the Salts of the Blood are rendered volatile and alcalious by Heat or Putrefaction ; because, the Thirst is great in such Fevers, as it is even in Health after a Meal of Fish, whose Salts are of an alcalious Nature. But these Rules we find to be just by Experience. And therefore, from the Demand of Nature we may judge of the Diet which is proper in Fevers.

*Hippocrates* for Diet in Fevers, used Barley Gruel thicker or thinner, more or less nourishing, according to the Nature and Circumstances of the

the Disease, Water sweetened with Honey and plain Water, a Mixture of Vinegar and Water either plain or sweetened with Honey, Vinegar sweetened with Honey, and Wines of various Kinds; of all which he has given an Account in his Treatise on Diet in acute Diseases. According to that great Man, “a moist  
“ Diet is proper for all Persons in  
“ Fevers. The Diet ought to be  
“ thinnest when the Fever is at the  
“ Height. Diet ought not to be  
“ given in the Exacerbations or Pa-  
“ roxysms of Fevers, because it  
“ hurts. Diet ought to be thinnest  
“ in the most acute Fevers, and less  
“ thin as Fevers are less acute. In  
“ Fevers which soon come to the  
“ Height, the Diet must be thin  
“ from the Beginning; but in Fe-  
“ vers which come later to the  
“ Height, the Diet must be thinner  
“ at and a little before that Time,  
“ but

“ but more nourishing before to en-  
 “ able the sick Person to hold out.  
 “ In the Beginning, the Gruel must  
 “ not be much, nor thick. Some  
 “ must be taken every Day, to pre-  
 “ vent an Emptiness of the Vessels;  
 “ and once or twice a Day, accord-  
 “ ing to the Custom of eating in  
 “ Health; only ’tis adviseable after  
 “ the first Day to give it twice a Day  
 “ rather than once, even to those  
 “ who have accustomed themselves  
 “ to eat but once a Day in Health.  
 “ Much Gruel must not be given,  
 “ even when the Disease is of the  
 “ most drying Nature; but before  
 “ the supping of it, must be drunk  
 “ Water sweetened with Honey, or  
 “ Wine, which ever shall be most  
 “ convenient. When any right  
 “ Discharge happens, as a right  
 “ Expectoration in a Pleurisy, the  
 “ Quantity of Gruel must be in-  
 “ creased, and that in Proportion to  
 “ the



“ the Discharge; for the more Bo-  
“ dies are then moistened, the  
“ quicker commonly will be the  
“ *Crisis*; and on the contrary. Nei-  
“ ther Gruel nor Drink ought to be  
“ given in Fevers, when the Feet are  
“ cold.

In Fevers attended with Inflammations, watry Fomentations and watry Cataplasms must be apply'd, where they conveniently can, to the inflamed Part; for they assist much in removing Inflammations, by attenuating the Blood and increasing the vibrating Motion of the Fibres. Accordingly, *Hippocrates* directed a Bladder filled with hot Water, or a large Sponge squeezed out of hot Water, to be apply'd to the Side affected in a Pleurisy.

*Opiats*, as they lessen the vibrating Motion of the Fibres, and the Motion of the Fluids consequent thereon, are useful in high Fevers  
in

in which the Heat of the Blood is too great for a just Concoction of the febrile Matter, and the Motion of the Blood too rapid for a compleat Separation of that Matter from the Blood; in all Evacuations which from their Violence endanger Life; in *Phrenfies* and *Deliriums* from too great a Motion of the Blood, which frequently happen before critical Eruptions in Fevers; in high Fevers attended with a *Catarrh*, or great *Watchfulness*; and in the *Small-Pox*, during the Time of *Suppuration*; for Rest and Sleep greatly promote Suppuration. Where *Opiats* are required in Fevers, the Greatness of the Dose and Frequency of repeating it may both be determined by the Effect which is intended to be produced by them; for if no Inconvenience arises on using *Opiats*, they may be given in such Quantities, and

so often repeated, as shall be necessary to attain the End proposed.

In *intermitting Fevers*, commonly called *Agues*, the Tenacity of the Blood is less than in continual Fevers, by *Schol. Prop. 44.* And the immediate Cause, that is, the Foulness of the Blood, is both less in Quantity and of a less fixed Nature in intermitting than in continual Fevers; as we may gather from the Shortness of the Paroxysms of the former, when compared with the Length of the Period of the latter. For it is rational to suppose the febrile Matter to be less or more in Quantity, and of a Nature less or more fixed, as it requires a lesser or a greater Time wherein to be concocted, separated from the Blood, and thrown out of the Body in a *Crisis*. The Blood is depurated (tho' not perfectly) by the Paroxysm of  
an

an Ague, in commonly less than one whole natural Day; whereas, many Days are ordinarily required for its Depuration by a continual Fever. The Return of the Paroxysms in intermitting Fevers shews, that, tho' the Fever terminates with each Paroxysm, yet the Blood is not perfectly depurated by it; some Degree of Foulness still remains in the Blood, which on account of its Smallness may not be sufficient to continue the Fever, but yet may be sufficient by Degrees to taint and foul the Blood again, so as to cause a new Paroxysm. For, the least Quantity of *variolous Pus*, introduced into the Blood of a Person in Health who has never had the *Small-Pox*, can so change the Texture of the Blood in the Compass of eight or ten Days, as to cause the same Disease: And in other Fevers, a small Quantity of febrile Matter



remaining in the Blood after an imperfect *Crisis* often occasions a Relapse or Return of the Fever. We learn from *Sanctorius*, that Bodies are heavier at the Beginning of intermitting Fevers than in Health; for he found by Experiments, that if the Increase of Weight which happens in Autumn exceeds the healthful Latitude of Weight, it causes tertian or other putrid Fevers. The Urine is pale in the Beginning of the Paroxysm, when the Body is cold; it becomes high coloured, when the Body is hot; and when the Paroxysm is over, it is reddish when made, and when cold lets fall a Brick-coloured Sediment; which Sediment always shews a Disease to be of the intermitting Kind. Of this Kind are remitting Fevers which are periodical in their Exacerbations; and out of them have a Brick-coloured Sediment in the Urine;

rine; and also *Colicks*, *Pleurisies*, *Rheumatisms*, or *Rheumatick Pains*, which are periodical and have this Urine. Intermitting Fevers, from Neglect or ill Treatment, often terminate in other Diseases, a *Dropfy*, *Jaundice*, &c. when the Heat and Motion of the Blood become too languid to form a febrile Paroxysm.

From the Increase of Weight, we may infer the Usefulness of Evacuations in the Beginning of intermitting Fevers. And we may know what Kind of Evacuations are proper, by the Account which has been given of Evacuations. After proper Evacuations are made, and the Patient has had a sufficient Number of Paroxysms, a Stop may be put to the Fever by the *Peruvian Bark*; a small Quantity of which will generally be sufficient for this Purpose, if it be taken in large Doses, and the Doses be repeated at short Intervals.

An

An Ounce, or at most two, will generally be sufficient in a grown Person. This Medicine strengthens the Fibres, and increases the Tenacity of the Blood, by *Prop.* 41. and its *Scholium*: And we may allow it to have a Power of lessening the Motion of the Blood, and contracting the Blood-vessels, by some Experiments made by Mr. *Hales*, of which I have given an Account in *Cor.* 6. *Prop.* 42. By these Effects it lessens the Frequency of the Pulse, checks or intirely stops feverish Effervescences in the Blood, makes foul and turbid Urine in Diseases to become clear and transparent, and is of great Efficacy, after proper Evacuations, in stopping *Hæmorrhages*, *Sweats*, and a *Diabetes*. Hence, the *Bark* is very improper, nay hurtful, in intermitting Fevers, till the Matter which fouls the Blood is so far concocted and thrown off by repeated

peated Paroxysms, that Nature with a proper Regimen is able to concoct and throw off the Remainder without the Assistance of a Fever. Accordingly, stopping intermitting Fevers by the *Bark* has always been found most effectual and safe, when some Paroxysms have passed before it has been given. The strengthening Quality of the *Bark* may be increased by mixing it with Things of a more strengthening Nature than it self, such as Salt of Tartar, or Sal-armoniac; and by washing down the Mixture with some strengthening Liquor, such as Claret, *German* Spa-water, or a Cordial in which plain Spirit of Wine, or some compound Water of the Shops, makes a considerable Part of the Composition.

All that remains to be said concerning Fevers is, to shew how to conduct the Patient after the Fever

is



is over, till he gathers Strength and is restored to perfect Health. If the *Crisis* has been perfect, there will be no Occasion for Medicines; for both Strength and Health may be restored by a proper Diet. The Food ought at first to be chiefly liquid; for liquid Food, as it is more easily digested, and on that Account can be taken in a greater Quantity, will be fitter for a weakened Body, and sooner repair the Waste made by the Disease, than solid Food. It ought by Degrees to be more solid, in order to give Driness and Strength to the weakened Fibres. But if the *Crisis* has been imperfect, the Patient must be purged in order to carry off the Remains of the Disease; and afterwards, nourished in the same manner as if the *Crisis* had been perfect. If the Fever be carried off by Sweating with the testaceous Powders, in the Manner above mentioned,

ed,

mentioned, the same Conduct must be used as after an imperfect *Crisis*, to prevent a Return of the Fever either in its old Form, or in the Form of an Ague.

*General SCHOLIUM.*

From what has been delivered in this and the last Section, we know, how to increase or lessen the Strength of the Fibres, and Tenacity of the Fluids; how to increase or lessen the vibrating Motion of the Fibres, and progressive Motion of the Fluids consequent thereon; by what Evacuations the whole Body, or any particular Part, ought to be emptied when it happens to be overloaded; and what are the proper Methods of correcting Irregularities in the Discharges, when it shall be judged safe to do it. A Discharge instituted by Nature, to take off a

R r r

Load

Load or Fulness, or to free the Body from irritating and hurtful Humours, ought not to be check'd by strengthening Medicines, or by turning the Course of the Fluids to other Parts of the Body; but be suffered to go on, and be promoted by large Dilution, or otherwise, if the Strength will allow, till the Ends of its Institution are attained. After which, it often stops of itself, when the Discharge has been of no long Continuance; but if it should not, it may be safely check'd by strengthening the Fibres of the Part from which the Discharge is made, and turning the Course of the Fluids from that to other Parts of the Body at the same Time. The Strength of the Body in Diseases is measured by the Force of the Heart, which Force may be judged of by the Motion of the Blood; and we know this Motion by the Magnitude  
and

and Frequency of the Pulse. We may judge of the Sharpness of irritating and hurtful Humours by the Pain which attends the Discharge. The remote Causes of chronical Diseases are, long Errors in the Nonnaturals, acute Diseases ill cured, a preternatural Weakness or ill Conformation of some particular Part, and a Taint in the Fluids and Solids either hereditary or acquired. Now, from a Knowledge of all these Particulars, the proper Methods of conducting chronical Diseases, as far as they are to be relieved by Art, may be so easily deduced, that it may seem unnecessary to descend to a particular Treatment of them.

*F I N I S.*



and frequency of the Pulse. We may judge of the sharpness of its rising and falling moments by the Pain which attends the Discharge. The various Causes of chronic Diseases are, long, Errors in the Nonnals, acute Diseases, all cured, a preternatural Weakness or Corruption of some part, or in Part, and a Taint in the blood, and Solids either ordinary or acquired. Now, from a knowledge of all this, we may determine the proper Methods of conducting chronic Diseases, as far as they are to be relieved, by Art, may be easily deduced, that it may seem unnecessary to attend to a particular Treatment of them.



A  
L E T T E R  
T O  
Dr. *C H E Y N E*,  
C O N T A I N I N G  
An Account of the Motion of Water  
through Orifices and Pipes;  
And an ANSWER to  
Dr. MORGAN's Remarks  
O N  
Dr. ROBINSON's Treatise  
O F T H E  
*Animal Oeconomy.*

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D U B L I N:

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A  
LETTER

TO

DR. CH. B. NICHOLS

OF

IN A DISCUSSION OF THE  
THEORY OF THE

UNION

DR. MORGAN'S THEORY

ON

DR. ROBINSON'S THEORY

OF THE

THEORY OF THE

DUBLIN

OF THE

OF THE



A  
 LETTER  
 TO  
 Dr. *CHEYNE*, &c.

*S I R,*



**N**OWING you to be a  
 Person of Candour and  
 Judgment, and through-  
 ly acquainted with Phi-  
 losophical Subjects, I take the Li-  
 berty to send you this Paper, which

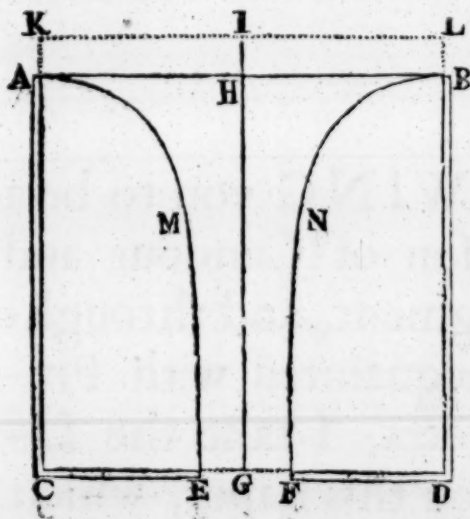
A 2                      contains



contains an Account of the Motion of Water through Orifices and Pipes, and a Vindication of my Treatise of the *Animal Oeconomy* from certain Objections offered against it by Dr. *Morgan*, in his late Book, intituled, *The mechanical Practice of Physick*.

### PROPOSITION I.

**I**F A C D B be a cylindrical Vessel filled with Water, A B its upper Orifice, C D its Bottom parallel to the Horizon, E F a circular Hole in the middle of the Bottom, G H the Axis



of the Cylinder perpendicular to the Horizon, GI the Axis produced till IH becomes equal to the Space thro' which a bea-

zy

*any Body must descend in vacuo to acquire a Velocity equal to the Velocity of the Water in the Surface AB; if A be put for the Area of the Surface of the Water AB, a for the Area of the Hole EF, H for GH the perpendicular Height of the Water in the Vessel above the Hole, V for the Velocity of the Water flowing through the Hole, and v for the Velocity of the Water in the Surface AB; and lastly, if the Vessel be supposed to be kept constantly full, by being supply'd at the Top as fast as the Water runs out through the Hole, and the Water descend from the Top of the Vessel to the Hole freely and without Resistance; I say that V will be equal to the Velocity acquired in falling in vacuo through the Space  $\frac{V^2 H}{V^2 - v^2}$  or  $\frac{A^2 H}{A^2 - a^2}$ , or  $\frac{IG \times H}{IG - IH}$ , or IG.*

For

For IH being the Space through which a heavy Body must fall *in vacuo*, to acquire a Velocity equal to the Velocity of the Water in the Surface AB, and the Water being supposed to descend from the Surface to the Hole freely and without Resistance, IG will be equal to the Space through which a heavy Body must fall *in vacuo* to acquire the Velocity of the Water in the Hole EF: But the Velocities acquired by a Body falling *in vacuo* through the Spaces IG and IH are in the subduplicate Ratio of those Spaces, on Supposition that the Gravity of the Body is the same in I as in G, as it will be without any sensible Error if the Point I be but at a small Distance from the Surface of the Earth; and the same Velocities V and v, are also as the Areas A and a, because equal Quantities of Water pass through the Surface AB and Hole EF

EF in the same Time; and therefore  $V.v::A.a::\sqrt{IG}.\sqrt{IH}$ ; and by Squaring, and Division of Proportion,  $\frac{V^2}{V^2-v^2}=\frac{A^2}{A^2-a^2}=\frac{IG}{IG-IH}=\frac{IG}{H}$ , and, by multiplying by H,  $\frac{V^2H}{V^2-v^2}=\frac{A^2H}{A^2-a^2}=\frac{IG\times H}{IG-IH}=\frac{IG\times H}{H}=IG$ : And therefore V will be equal to the Velocity acquired by falling *in vacuo* through the Space  $\frac{V^2H}{V^2-v^2}$ , or  $\frac{A^2H}{A^2-a^2}$ , or  $\frac{IG\times H}{IG-IH}$ , or IG. Which was to be proved.

*Cor. 1.* H, the perpendicular Height of the Water in the Vessel, is  $=IG \times \frac{V^2-v^2}{V^2}=IG \times \frac{A^2-a^2}{A^2}$ .

*Cor. 2.* V, the Velocity with which the Water flows through the Hole,



Hole, is as  $\sqrt{\frac{V^2 H}{V^2 - v^2}}$ , or as  $\sqrt{\frac{A^2 H}{A^2 - a^2}}$ , Or  
as  $\sqrt{\frac{IG \times H}{IG - IH}}$ , or as  $\sqrt{IG}$ .

*Cor. 3.* If  $a$  be equal to  $A$ ,  $V$  will be nothing. For when  $a$  is equal to  $A$ ,  $v$  will be equal to  $V$  by this *Proposition*: But when  $a=A$ , and  $v=V$ ,  $H$  will be nothing by *Cor. 1.* And consequently  $V$  will be nothing by *Cor. 2.*

The Truth of this *Corollary* will appear likewise, by considering that when  $a$  is equal to  $A$ ,  $IH$  will be equal to  $IG$ , and the Point  $H$  will coincide with the Point  $G$ : But when the Point  $H$  coincides with the Point  $G$ , the perpendicular Height of the Water in the Vessel will be destroy'd, and when the perpendicular Height of the Water in the Vessel is destroy'd, there can be

be no Velocity: And therefore when  $a=A$ ,  $V$  will be nothing.

Farther, to suppose  $a$  to be equal to  $A$ , and consequently  $v$  to be equal to  $V$ , will from the Nature of Gravity make  $V$  nothing. For Gravity accelerates the Motion of the Water from the Surface to the Hole, and makes the Velocity through the Hole greater than at the Surface, while there is the least perpendicular Distance between them; and therefore to make the two Velocities equal, will be to destroy the perpendicular Height of the Water in the Vessel: But when the perpendicular Height of the Water is destroy'd, there can be no Velocity: And therefore to suppose  $v$  to be equal to  $V$ , will be to make  $V$  nothing.

From all this it appears, that the Velocities  $v$  and  $V$  can never become equal, but in the Instant of their Evanescence on an infinite Di-

B

minution

Diminution of the perpendicular Height of the Water in the Vessel, and a consequent Coincidence of the Points I and H with the Point G.

*Cor. 4.* If  $A$  be greater than  $A$ ,  $H$  will be negative, and  $V$  will be affirmative. For when  $a$  is greater than  $A$ ,  $A^2 - a^2$  will be negative, and consequently  $H$  will be negative by *Cor. 1.* And, when  $A^2 - a^2$  and  $H$  are both negative,  $V$ , the Velocity with which the Water flows through the Hole, will be affirmative by *Cor. 2.*

A negative perpendicular Height of the Water in the Vessel, and an affirmative Velocity necessarily require an Inversion of the Vessel, or turning of its Bottom upwards, by which Inversion the Hole will become the upper Orifice and the upper Orifice become the Hole,  $a$  will become

become A, and A will become a, v will become V, and V become v, and the Velocity will be affirmative, that is, the Water will move downwards, as it ought to do from the Nature of Gravity. That an Inversion of the Vessel is necessary, will appear farther by the following Argument. When a is greater than A, the Vessel will be conical with its wider End downwards: But, from the Nature of Gravity, Water poured in at the Top or narrower End of such a Vessel, will descend in a cylindrical Column, which cannot fill the Base, as this *Proposition* requires: And therefore there must be an Inversion of the Vessel, and such a Change of Symbols as I have mentioned.

*Cor. 5.* If the Hole be exceeding small in comparison of the upper Orifice, the Velocity with which



the Water flows through the Hole, will, without any sensible Error, be equal to the Velocity which a heavy Body will acquire in falling *in vacuo* through a Space equal to the perpendicular Height of the Water in the Vessel, that is,  $V$  will, without any sensible Error, be equal to the Velocity acquired in falling *in vacuo* through a Space equal to  $H$ . For when  $a$  is exceeding small in comparison of  $A$ ,  $A^2 - a^2$  will be very nearly equal to  $A^2$ , and  $\frac{A^2 H}{A^2 - a^2}$  will be very nearly equal to  $H$ : But, by this *Proposition*,  $V$  is equal to the Velocity acquired in falling *in vacuo* through a Space equal to  $\frac{A^2 H}{A^2 - a^2}$ : And therefore  $V$  will be very nearly equal to the Velocity acquired in falling *in vacuo* through a Space equal to  $H$ .

*Cor.*

*Cor. 6.* The Force which can generate the whole Motion of the Water flowing out thro' the Hole, is equal to the Weight of a Cylinder of Water whose Base is the Hole, and whose Altitude is twice the Space through which a heavy Body must fall *in vacuo* to acquire the Velocity with which the Water flows through the Hole; that is, the Force is equal to the Weight of the Cylinder of Water  $a \times 2 \text{ IG}$ . For the Time, in which the Water flowing out through the Hole becomes equal to the Cylinder of Water  $a \times 2 \text{ IG}$ , is equal to the Time in which that Cylinder of Water in falling *in vacuo* by the constant Action of its own Weight will acquire a Velocity equal to that with which the Water flows out, that is, a Velocity equal to  $V$ ; and from an Equality of the Times of the Motions, of the Quantities

tities of Matter moved, and of the Velocities, the Motions of the effluent Water and of the descending Cylinder will be equal: But when two Motions are equal, the Forces generating those Motions are equal: And consequently, the Force which can generate the whole Motion of the Water flowing out through the Hole, is equal to the Weight of a Cylinder of Water whose Magnitude is  $a \times 2 \text{ I G}$ .

#### SCHOLIUM.

Since, by this *Proposition*, the Velocity with which the Water flows through the Hole, is equal to the Velocity which a Body will acquire by falling *in vacuo* through a Space equal to  $\frac{A^2 H}{A^2 - a^2}$ , on Supposition that the Water descends down the Vessel freely and without Resistance; we may,

may, by knowing the Velocity acquired by a heavy Body in falling through such a Space, find the Velocity with which the Water flows out through the Hole. For, according to Sir *Isaac Newton*, a Body falling *in vacuo* near the Surface of the Earth will describe  $193\frac{1}{3}$  Inches or  $16\frac{1}{9}$  Feet in one Second Minute of Time, and will have acquired a Velocity in the Time of the Fall, which being continued uniform would make it describe twice that Space, that is  $386\frac{2}{3}$  Inches or  $32\frac{2}{9}$  Feet in one Second: But uniform Velocities are as the Spaces described by them in one Second, and the Velocities acquired in falling *in vacuo* through the Spaces  $16\frac{1}{9}$  and  $\frac{A^2 H}{A^2 - a^2}$  are in the subduplicate Ratio of those Spaces: And therefore  $32\frac{2}{9} \cdot \sqrt{16\frac{1}{9}} :: V \cdot \sqrt{\frac{A^2 H}{A^2 - a^2}}$ ; whence  $V =$

8.02773



$$8.02773 \sqrt{\frac{A^2 H}{A^2 - a^2}} \text{ Feet} = 96.33276$$

$\sqrt{\frac{A^2 H}{A^2 - a^2}}$  Inches. This is the Velocity with which the Water flows through the Hole, setting aside the Resistance of the Air, and supposing the Water to descend down the Vessel freely and without Resistance.

The true Velocity with which the Water flows out through the Hole, will be had by applying the Quantity of Water discharged by Experiment, to the Area of the Hole and Time of the Discharge taken together; that is, putting  $Q$  for the Quantity of the Discharge in cubick Inches,  $D$  for the Diameter of the Hole in Inches or Parts of an Inch, and  $T$  for the Time of the Discharge in Seconds, by  $\frac{Q}{.7853816 D^2 T}$ .

Now if the Water descend freely and without Resistance, this Measure

sure of the Velocity will be equal to  
 the former, that is,  $\frac{Q}{.7853816 D^2 T}$   
 $= 96.33276 \sqrt{\frac{A \cdot H}{A^2 - a^2}}$ ; whence  $Q =$   
 $75.65957 D^2 T \sqrt{\frac{A \cdot H}{A^2 - a^2}}$ , and, putting  
 W for the Weight of this Bulk of  
 Water in Ounces *Troy*,  $W =$   
 $39.93144 D^2 T \sqrt{\frac{A \cdot H}{A^2 - a^2}}$ . But it has  
 been found by Experiments, that the  
 Bulk and Weight of Water discharg-  
 ed, always fall considerably short of  
 what they ought to be by these  
 Rules; Sir *Isaac Newton* found them  
 to be less in the Proportion of 441  
 to 625, or of 1 to  $\sqrt{2}$  nearly: And  
 therefore Q and W must both be  
 lessened in this Proportion, and  
 then we shall have  $Q = 67.97239$   
 $\sqrt{\frac{A \cdot H}{A^2 - a^2}}$ , and  $W = 53.38426 D^2 T$   
 $\sqrt{\frac{A \cdot H}{A^2 - a^2}}$ .

C

That

That less Water flows through the Hole in a given Time, than would flow through it if the Water descended down the Vessel without any Resistance, must be owing either to the Water's not filling the Hole when it passes through it, or to its passing through it with a less Velocity than that which is required in falling *in vacuo* through a Space equal to  $\frac{A \cdot H}{A - a}$  : But by carefully observing the Water as it flows out, I find that it fills the Hole if the Plate in which the Hole is made be very thin, and if the Plate be thick and the Hole be a short Pipe, that it fills the inner Orifice of the Pipe which is contiguous to the Water in the Vessel, though it does not fill the outer Orifice on account of the Contraction of the Vein, which Contraction extends from the inner Orifice of the Pipe, which is to be  
con-

considered as the Hole, to about the Distance of its Diameter : And therefore the Water passes through the Hole with a less Velocity than that which is acquired in falling *in vacuo* through a Space equal to

$$\frac{A^2 H}{A^2 - a^2}.$$

It passes through the Hole with a less Velocity, from its not descending freely and without Resistance, and it does not descend freely and without Resistance from its moving laterally as well as downwards throughout its Passage from the upper Orifice to the Hole. The lateral Motion of the Water, or the flowing together of its Parts from all Sides of the Vessel throughout its whole Descent, gives a Resistance to its Motion downwards, and that Resistance lessens the perpendicular Velocity, and makes the Quantity of Water discharged in a given Time less than it would be if there



was no such lateral Motion, but the Water descended only perpendicularly from AB to EF.

The Velocity therefore with which the Water flows through the Hole, is equal to the Velocity which a heavy Body would acquire in falling *in vacuo* through a Space equal to one half of the Space  $\frac{A^2 H}{A^2 - a^2}$ . For the Velocity with which the Water flows through the Hole, is to the Velocity acquired in falling *in vacuo* through the Space  $\frac{A^2 H}{A^2 - a^2}$  as 1 to  $\sqrt{2}$ , from Sir *Isaac Newton's* Experiments: But from the Law of the Descent of heavy Bodies *in vacuo*, the Velocity acquired in falling through one half of the Space  $\frac{A^2 H}{A^2 - a^2}$  is to the Velocity acquired in falling through the whole Space  $\frac{A^2 H}{A^2 - a^2}$  as 1 to  $\sqrt{2}$ : And therefore the Velocity

city with which the Water flows thro' the Hole is equal to the Velocity acquired by falling *in vacuo* through one half of the Space  $\frac{A^2 H}{A^2 - a^2}$ .

The true Quantity of Water discharged will likewise be had by supposing the Velocity with which the Water flows through the Hole to be equal to that which a heavy Body will acquire in falling *in vacuo* through the Space  $\frac{A^2 H}{A^2 - a^2}$ , and the Hole to be contracted and its Area lessened in the Proportion of 441 to 625 or 1 to  $\sqrt{2}$ . For, since the Quantity of Water discharged is as the Velocity with which the Water flows through the Hole, the Area of the Hole, and Time of the Motion taken together, it is evident that the same Quantity of Water will be discharged in a given Time, whether the Velocity acquired in falling

falling *in vacuo* through the Space  $\frac{A^2 H}{A^2 - a^2}$ , or a the Area of the Hole, be lessened in the Proportion of 1 to  $\sqrt{2}$ . Sir *Isaac Newton* found the Area of a transverse Section of the Vein at the Distance of about a Diameter from the Hole, to be less than the Area of the Hole in the said Proportion. And in the Determination of this Motion he supposes the Hole to be contracted in that Proportion, and the Velocity, with which the Water flows through it, to be equal to the Velocity in the contracted Part of the Vein, that is, equal to the Velocity which a heavy Body will acquire in falling *in vacuo* through G I, or  $\frac{A^2 H}{A^2 - a^2}$ .

In order to know, whether the Velocities of Water flowing through circular Holes of different Diameters at the same perpendicular Distance

stance from the Surface of the Water, be all equal, and what Relation the Velocity of Water flowing through a Hole bears to the Velocity of Water flowing through a Pipe of an equal Diameter and at an equal perpendicular Distance from the Surface of the Water, I got Mr. *Stokes*, a skilful and accurate Mathematical Instrument-maker in this City, to make a very exact *Apparatus* for ascertaining these Things by Experiments. And from the Experiments I composed the two following Tables.

The first Table contains, in the first Column the Time of the Discharge in Seconds, in the second the perpendicular Heights of the Water above the Hole in *London* Feet, in the third the Diameters of the Holes in Parts of an Inch, in the fourth the Weights of Water discharged in Ounces *Troy*, and in the



| TABLE I. |   |                |        |                 |
|----------|---|----------------|--------|-----------------|
| T        | H | D              | V      | $\frac{V}{D^2}$ |
| 5"       | 4 | $\frac{2}{10}$ | 13.267 | 3317            |
|          |   | $\frac{4}{10}$ | 49.    | 3062            |
|          |   | $\frac{5}{10}$ | 76.    | 3040            |
|          |   | $\frac{8}{10}$ | 186.   | 2906            |
|          | 2 | $\frac{2}{10}$ | 9.     | 2250            |
|          |   | $\frac{4}{10}$ | 35.    | 2193            |
|          |   | $\frac{5}{10}$ | 54.    | 2160            |
|          |   | $\frac{8}{10}$ | 133.75 | 2090            |

the fifth the Velocities measured by the Weights of Water discharged apply'd to the Squares of the Diameters of the Holes.

By this Table, the Velocities of Water flowing through Holes of different Diameters, and at the same perpendicular Distance from the Surface of the Water, are all nearly equal; only the Velocity is ever some-

something greater through a smaller Hole than through a larger.

The second Table consists of three Parts, and each Part of three Columns. The first Column of each Part contains the Diameter of

| TABLE II.      |      |        |                |      |       |                |      |        |
|----------------|------|--------|----------------|------|-------|----------------|------|--------|
| D              | L    | V      | D              | L    | V     | D              | L    | V      |
| $\frac{1}{10}$ | O    | 13.267 | $\frac{4}{10}$ | O    | 49.   | $\frac{8}{10}$ | O    | 186.   |
|                | D    | 14.985 |                | D    | 57.   |                | D    | 213.25 |
|                | 2 D  | 15.    |                | 2 D  | 58.5  |                | 2 D  | 234.   |
|                | 3 D  | 14.367 |                | 3 D  | 55.   |                | 3 D  | 226.5  |
|                | 4 D  | 14.300 |                | 4 D  | 54.5  |                | 4 D  | 221.   |
|                | 5 D  | 14.233 |                | 5 D  | 53.75 |                | 5 D  | 212.   |
|                | 10 D | 13.212 |                | 16 D | 49.   |                | 16 D | 196.   |
|                |      |        |                |      |       |                | 23 D | 186.   |

the Pipe in Parts of an Inch, the second the Lengths of the Pipes beginning from O, that is from an Hole, and the third the Velocities expressed by the Weights of Water discharged in five Seconds of Time. The Holes and Pipes were all at the

D                      Distance

Distance of 4 Feet from the Surface of the Water, and the Pipes lay all parallel to the Horizon.

By this Table, the Velocity increases from the Hole till the Length of the Pipe becomes equal to about twice its Diameter, that is, equal to about  $2D$ , and is greater there than at any other Length of the Pipe. The greatest Velocities in these Pipes in Proportion to the Velocities through their respective Holes, which Holes may be considered as Pipes of infinitely small Lengths, are as the Numbers 1130, 1215 and 1258, in Proportion to 1000: Whence we learn, that the greatest Velocity in a Pipe in Proportion to the Velocity through an Hole of an equal Diameter and at an equal perpendicular Distance from the Surface of the Water, is something greater in a wider Pipe than in a narrower one.

From

From the Length  $2 D$ , the Velocity lessens continually on increasing the Length of the Pipe, and becomes equal to the Velocity thro' the Hole, when the Length of the Pipe becomes equal to  $25.71478 D \sqrt{D}$ . For the Velocities through the Pipes were nearly equal to the Velocities through their respective Holes, when the Lengths of the Pipes were  $10 D$ ,  $16 D$ , and  $23 D$ , that is,  $2$ ,  $6.4$ , and  $18.4$  Inches: But  $2$ ,  $6.4$ , and  $18.4$ , are nearly in the sesquiplicate Ratios of the Diameters  $\frac{2}{10}$ ,  $\frac{4}{10}$ , and  $\frac{8}{10}$ : And therefore  $18.4 \cdot \frac{8}{10} \times \sqrt{\frac{8}{10}} :: L \cdot D \sqrt{D}$ ; whence  $L = 25.71478 D \sqrt{D}$  nearly.

From five times that Length of a Pipe forward at which the Velocity is equal to the Velocity through an Hole of an equal Diameter, that is, from the Length  $128.5739 D \sqrt{D}$  forward, the Velocity will be measured nearly by the inverse subduplicate

$D^2$

cate



cate Ratio of the Length of the Pipe;  $V$  will be nearly as  $\frac{1}{\sqrt{L}}$ . For, by the first Experiment, *Anim. Oecon.* p. 29, the Velocities in two Pipes, whose Lengths were 2 Feet and 8 Feet, and whose common Diameter was  $\frac{345}{1000}$  Parts of an Inch, were nearly in the reciprocal subduplicate Ratios of the Lengths of the Pipes: But  $128.5739 D\sqrt{D}$  is nearly equal to 2 Feet, the Length of the shorter Pipe: And therefore from the Length  $128.5739 D\sqrt{D}$  forward, the Velocity will be measured nearly by the reciprocal subduplicate Ratio of the Length of the Pipe;  $V$  will be nearly as  $\frac{1}{\sqrt{L}}$ . Hence it follows, that from the Length  $128.5739 D\sqrt{D}$  forward, the Rectangle under the Velocity and square Root of the Length of the Pipe will be given; that is,  $V\sqrt{L}$  will be given,

given, or be the same in Pipes of Lengths greater than 128.5739  $D\sqrt{D}$ . It was nearly so in Pipes of half an Inch in Diameter, and of different Lengths from a Pipe of 4 Feet in Length to one of 100, when the perpendicular Height of the Water in the Vessel was 3 Feet. From the Nature of the Motion of Water through Pipes, I think there must be a certain Length of a Pipe of a given Diameter beyond which  $\frac{1}{\sqrt{L}}$  does not measure the Velocity; but what that Length is I cannot say for want of Experiments.

The Reason why this Measure of the Velocity does not begin to obtain till the Pipe be of a certain Length, may be this. The lateral Motion of the Water descending in the Vessel, which Motion has been shewn to affect and disturb the Motion of Water flowing through a Hole,

Hole, may likewise affect and disturb its Motion through a Pipe, and hinder  $\frac{1}{\sqrt{L}}$  from being an accurate Measure of the Velocity till the Pipe comes to be of such a Length, that the Resistance arising from the Weight of Water in the Pipe and from the internal Surface of the Pipe can in a good measure correct this Disturbance; that is, till it comes to be of the Length  $128.5739 D\sqrt{D}$ . And if this be the Reason why this Measure of the Velocity does not obtain with any Accuracy, till the Pipe comes to be of the Length  $128.5739 D\sqrt{D}$ ; then the Velocity with respect to  $\frac{1}{\sqrt{L}}$  in Pipes exceeding this Length, will be always something greater in a longer Pipe than in a shorter one (because the Correction of the Disturbance is greater in the former than in the latter)

latter) as I have always found it to be by Experiments.

This may suffice concerning the Motions of Water through Orifices and Pipes. I shall now proceed to Dr. *Morgan's* R E M A R K S, and shall shew that they have all been occasioned by his not having duly attended to what Sir *Isaac* and I delivered concerning these Motions.

In p. 68. l. 4, 5. the Doctor says that *F will ever be as  $D^2 H$* , whereas had he attended to *Prop. 36. lib. 2. Newton.* he would have seen that *F* will never be as  $D^2 H$ , but when the Area of the Hole is infinitely little in comparison of the Area of the Surface of the Water in the Vessel, and the Pipe lies parallel to the Horizon. For I have shewn from that *Proposition*, that the Force which can generate the Motion of Water flowing through a Hole, is equal to  
the



the Weight of a Cylinder of Water whose Magnitude is  $a \times IG$ , or  $a \times \frac{A^2 H}{A^2 - a^2}$ : But this Force is evidently equal to the Force, which generates the Motion of Water flowing thro' a Pipe lying parallel to the Horizon, of an equal Diameter with the Hole, and inserted into the inside of the Vessel at an equal perpendicular Distance from the Surface of the Water.

1. The Doctor supposes  $D$  and  $H$  to be given, and consequently the moving Force, which is as  $D^2 H$ , to be given; in which Case  $V$  will be measured by  $\sqrt[1]{L}$ ; and then affirms, *that if  $L$  be infinitely small,  $V$  must be infinitely great, and if  $L$  be infinitely great,  $V$  will be infinitely small.* Here I must acquaint this Author, that it by no means follows from  $L$  being infinitely small, that  $V$  must

V must be infinitely great, any more than it follows from a Body's being ing divisible *in infinitum*, that the Magnitude of that Body must be infinite. A finite Body will be infinitely great with respect to any of its Particles, when it is divided or supposed to be divided *in infinitum*; and a finite Velocity of Water flowing through a Hole, which may be considered as an infinitely short Pipe, will be infinitely great with respect to the Velocity of Water flowing through a Pipe infinitely long: And yet it is evident that neither the Body nor the Velocity through the Hole is infinite. Small and great, infinitely small and infinitely great, are Terms including a Comparison of Things with one another; thus a Thing is called small in comparison of a Thing of the same Kind which is great, and infinitely small in comparison of a

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Thing which is infinitely great; a Hole is a Pipe of an infinitely small Length, in comparison of a Pipe infinitely long. And therefore, since  $V$  is as  $\sqrt[3]{L}$ , the Velocity of Water flowing thro' an Hole will be infinitely greater than the Velocity of Water flowing thro' an infinitely long Pipe, tho' in reality the Velocity thro' the Hole be finite, and no greater than the Velocity acquired in falling *in vacuo* thro'  $\frac{A^2 H}{A^2 - a^2}$ .

2. The Doctor, p. 69, supposes  $D$  to be given, and  $H$  to be proportional to  $L$ ; in which Case the Velocity thro' the Pipe will be given. However strange and absurd this may appear to this Gentleman, I can assure him I have found it to be true by Experiments. Two Pipes of the same Diameter, whose Lengths

Lengths were 8 Feet and 2 Feet, placed at the Distances of 4 Feet and 1 Foot from the Surface of the Water, discharged 97 and 83 *Troy* Ounces of Water in half a Minute. The Quantity discharged by the shorter Pipe was something less than the Quantity discharged by the longer, which was owing to the Disturbance arising from the lateral Motion of the Water descending in the Vessel, which is ever greater in a shorter Pipe than in a longer, and at a less Distance from the Surface of the Water than at a greater.

3. In his third Consequence, p. 70, drawn from V being as  $\sqrt{\frac{DH}{L}}$ , this Author supposes *L* to be given, and *D* to be as  $\frac{1}{H}$ ; in which Case the Velocity will be given. He thinks this very absurd, as I gather from his fifth Consequence, in which he

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says



says expresly, *that D and L have nothing to do in the Matter, and cannot alter the Velocities at all.* But in this he is greatly mistaken; for both the Diameter and Length of a Pipe affect the Motion of Water moving thro' it, and are necessarily to be taken into the Measure of the Velocity, as fully appears from the first and second Experiments in the Proof of *Prop. 1. Anim. Oecon.* And I shall now shew by an Experiment, that the Velocity of Water flowing thro' a Pipe of a given Length is nearly the same, when the Diameter of the Pipe is inverfly as its perpendicular Distance from the Surface of the Water; that is,  $V$  will be given, when  $D$  is as  $\frac{1}{H}$ . Two Pipes, of the same Length, whose Diameters were 1 and 2, placed at the Distances of 2 and 1 from the Surface of the Water, discharged 68 and

20 Ounces of Water in half a Minute. The Velocities from these Discharges were as the Numbers 17 and 20. The first Velocity was something less than the second; because the first Pipe was wider and nearer to the Surface of the Water than the second, and consequently the Disturbance given to the Motion thro' the first, was greater than the Disturbance given to the Motion thro' the second.

4. In his fourth Consequence, p. 70, he supposes *H and L to be given; in which Case the Velocity will be as  $\sqrt{D}$* . However absurd this Consequence may appear to the Doctor, I have proved it true by the second Experiment in the Proof of *Prop. 1. Anim. Oecon.* to which I refer him.

5. In his fifth and last Consequence, p. 70, he supposes *D and L to be given; in which Case V will be as  $\sqrt{H}$* . This he allows to be true,

true, and says it is the true Law of accelerating Gravity and Pressure as determined by Newton. But in this he is mistaken. For  $V$  is not as  $\sqrt{H}$  according to Newton, but as  $\sqrt{\frac{A'H}{A^2 - a^2}}$ , by Cor. 2. of the foregoing Proposition.

The Doctor proceeds to shew the Absurdity of what I asserted in my *Animal Oeconomy* from Sir Isaac Newton, and have demonstrated in the foregoing Proposition, namely, that the Velocity of Water flowing thro' a Hole is equal to the Velocity acquired by a heavy Body in falling *in vacuo* through the Space  $\frac{A'H}{A^2 - a^2}$ .

1. If this be the Space, p. 71, 72, through which a heavy Body must fall in *vacuo* to acquire a Velocity equal to the Velocity with which the Water flows through the Hole, then  $V$  will be as  $\sqrt{\frac{A'H}{A^2 - a^2}}$ . Now upon this

*this Supposition, let the differential Quantity  $A^2 - a^2$  be infinitely small, or let  $a$  be only not equal to  $A$ , and then the Expression  $\frac{A \cdot H}{A^2 - a^2}$  will be infinitely great; and consequently the Space described, as well as the Velocity acquired, will be infinite, where the perpendicular Pressure or Height of the Fluid is only finite and given; or which is the same thing, the Spaces described and the Velocities acquired, will be finite and infinite at the same Time and from the same Causes. Here again the Doctor is greatly mistaken. For by the third Corollary of the preceding Proposition, (which Proposition is a plain and obvious Consequence of Prop. 36. lib. 2. Newton.) when  $a$  is equal to  $A$ , the Space described and Velocity are so far from being infinite, that both will be nothing. His Mistake here arose from his not knowing that when  $a$*   
*is*

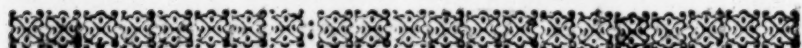


is equal to A, H will be nothing, by Cor. 1.

2. The Doctor goes on to shew the Absurdity of my Assertion in the following Words, p. 72. *Let the differential  $A^2 - a^2$  be infinitely small but negative, and then the Expression  $\frac{A^2 H}{A^2 - a^2}$  will be negative, but infinite still; the Consequence of which must be, that the Fluid in this Case cannot descend and flow thro' the Orifice a at all; but on the contrary must ascend perpendicularly, and flow upwards with an infinite Velocity, in a Direction quite contrary to that of Gravity.* Here likewise the Doctor is mistaken. For when a is greater than A, H will be negative, and V affirmative, by Cor. 4. And when H is negative the Vessel must be inverted, or turned with its Bottom upwards, which being done this Objection will vanish, by Cor. 4.

Having

Having shewn the Weakness of the Doctor's *Remarks* on my first *Proposition*, I shall beg leave, before I answer his *Remarks* on my 24th *Proposition*, to give a Demonstration of the Law of the Blood's Motion, exhibited in *Prop.* 12, independent of my first Section concerning the Motion of Fluids thro' cylindrical Pipes; because this Author seems to think, that all the mathematical Part of my Book depends on the Truth of that Section.



## PROPOSITION II.

**I** *F two healthful and perfectly well-proportion'd Bodies be situated alike with respect to the Horizon, if their Hearts be free from the Influences of all disturbing Causes, and the Capacities of the two corresponding Ven-*  
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*trices be proportional to the Capacities of the two whole Systems of Blood-vessels or of any two corresponding Blood-vessels, and if the Numbers of their Pulses in a given Time be inversely as the Times of two Systoles of their Hearts; the Velocities of their Blood in two corresponding Blood-vessels will be in the subduplicate Ratio of the Diameters of the Vessels, that is, putting V, v for the Velocities, and D, d for the Diameters of the Vessels,  $V. v :: \sqrt{D} . \sqrt{d}$ .*

For the Velocities in any two Blood-vessels, and consequently in two corresponding Blood-vessels, of the two Bodies, are as the Quantities of Blood which flow into those Vessels in two Systoles of their Hearts, apply'd to the Squares of the Diameters of the Vessels and the Times of the two Systoles taken together; and the Quantities of Blood  
which

which flow into the Vessels in two Syctoles, are as the Capacities of the corresponding Ventricles of the Hearts, because the Hearts are supposed to be free from the Influences of all disturbing Causes, and the Bodies to be situated alike with respect to the Horizon; and therefore, putting  $L, l$  for the Lengths of two corresponding Blood-vessels, or for the Lengths of the two Bodies, to which the Lengths of corresponding Blood-vessels are ever proportional in perfectly well-proportion'd Bodies, and  $T, t$  for the Times of two Syctoles, we shall have  $V. v :: \frac{D^2 L}{D^2 T} \cdot \frac{d^2 l}{d^2 t} :: \frac{L}{T} \cdot \frac{l}{t}$ : But by Supposition  $P. p :: \frac{1}{T} \cdot \frac{l}{t}$ : And therefore  $V. v :: LP. lp$ .

By observing the Pulses of healthful Bodies of different Lengths in the Morning when they were sitting,



ting, I have found that the mean Numbers of Pulses in a Minute of Bodies of any two different Lengths, each Mean being taken from the Pulses of a Number of Bodies of each Length, are very nearly as

$\frac{1}{L^{\frac{3}{4}}}$  and  $\frac{1}{l^{\frac{3}{4}}}$ : But the mean Numbers of Pulses in a Minute of Bodies of those two Lengths, are the true Pulses of two healthful and perfectly well-proportion'd Bodies: And therefore  $P . p :: \frac{1}{L^{\frac{3}{4}}} . \frac{1}{l^{\frac{3}{4}}}$ .

And by comparing the Diameters of the Aorta of Bodies of different Lengths with the Lengths of the Bodies, as far as I can judge from the few Experiments I made, the Diameters are nearly in the subduplicate Ratios of the Lengths: But the mean Diameters of the Aorta of Bodies of two different Lengths, each Mean being taken from the  
Dia-

Diameters of this Vessel of a Number of Bodies of each Length, are the true Diameters of the Aorta of two healthful and perfectly well-proportion'd Bodies of those Lengths: And therefore  $D . d :: \sqrt{L} . \sqrt{l}$ , and  $\sqrt{D} . \sqrt{d} :: L^{\frac{1}{4}} . l^{\frac{1}{4}}$ .

And therefore in the Analogy  $V . v :: LP . lp$ , if instead of  $P$  and  $p$ , be substituted the Quantities  $\frac{1}{L^{\frac{1}{4}}}$  and  $\frac{1}{l^{\frac{1}{4}}}$  proportional to them, we shall have  $V . v :: L^{\frac{1}{4}} . l^{\frac{1}{4}}$ ; and since  $L^{\frac{1}{4}} . l^{\frac{1}{4}} :: \sqrt{D} . \sqrt{d}$ , we shall have  $V . v :: \sqrt{D} . \sqrt{d}$ . Which was to be proved.

This *Proposition* may be express'd generally, by supposing  $P . p :: \frac{1}{L^m} . \frac{1}{l^m}$ , and  $D . d :: L^n . l^n$ . For then  $V . v :: L^{1-m} . l^{1-m} :: D^{\frac{1-m}{n}} . d^{\frac{1-m}{n}}$ . Hence, if hereafter it shall be

be found by a larger Experience, that the Measures of the Pulses and Diameters of corresponding Blood-vessels are different from those assigned in this *Proposition*, the Proportions of the Velocities in healthful and perfectly well-proportion'd Bodies of different Lengths, may be known.

For Instance, if it shall be found that  $m$  instead of being equal to  $\frac{3}{4}$  is equal to  $\frac{1}{2}$ , and that  $n$  is  $\frac{1}{2}$  as I have made it; then  $V.v :: \sqrt{L} . \sqrt{l} :: D.d$ . And if it shall be found, that  $m$  is  $\frac{4}{5}$  and  $n$   $\frac{1}{2}$ , then  $V . v :: L^{\frac{1}{5}} . l^{\frac{1}{5}} :: D^{\frac{4}{5}} . d^{\frac{4}{5}}$ . The Proportions of the Pulses and Diameters of corresponding Blood-vessels delivered from Experiments in this *Proposition*, are, as far as I can judge, intirely agreeable to the Phænomena, and therefore I shall retain them till a larger Experience shall shew that they are not  
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the Proportions which obtain in Nature.

I now come to consider the Doctor's Remarks on my 24th *Proposition*, which *Proposition* stands thus.

**T**HE Life of Animals is preserved by acid Parts of the Air mixing with the Blood in the Lungs; which Parts dissolve or attenuate the Blood, and preserve its Heat, and by both these keep up the Motion of the Heart.

I proved this *Proposition* from a Series of Experiments taken from Sir Isaac Newton, Dr. Hook, Dr. Lower, and others. And the Manner in which I proved it was this.

From Experiments I proved *first*, that a constant Supply of fresh Air is necessary to preserve the Life of Animals; *secondly*, that fresh Air preserves Life in Animals by the very  
same



same Power, or by the Operation  
 of the very same Parts, whereby it  
 preserves Fire and Flame in sulphu-  
 reous and unctuous Substances when  
 once they are kindled; and *thirdly*,  
 that Air preserves Fire and Flame in  
 sulphureous and unctuous Substances  
 when once they are kindled, and  
 consequently the Life of Animals,  
 by its acid Particles. Had this Au-  
 thor attended to the Experiments  
 from which I proved the second and  
 third Particulars, he could not but  
 have seen that they were justly pro-  
 ved. For, since Animals die in Air  
 rendered effete by burning Coals or  
 Candles in it till they are extinguish-  
 ed, and glowing Coals or Candles  
 are extinguished in Air rendered ef-  
 fete by Animals breathing in it till  
 they die; it clearly follows, that  
 Air preserves Fire and Flame, and  
 the Life of Animals, by the same  
 Power, or by the Operation of the  
 same

same Parts : And, since Fire and Flame can be produced without Air by mixing compound Spirit of Nitre, which is an Acid, in a certain Proportion with some Oils *in vacuo*, and can be preserved without Air in a Mixture of common Sulphur and Nitre powdered when once it is kindled, it follows that Air preserves Fire and Flame in sulphureous and unctuous Substances when once they are kindled, and the Life of Animals, by means of its acid Particles. There is no way of proving this Inference to be false, but by proving that there are no acid Particles in the Air. But the Air abounds with such Particles, as appears from the Nitre, which is found sticking to the Sides of plaistered Walls, and to the Mortar between the Bricks of Brick Walls, which are defended from the Rain which would dissolve it, and from

the Sun which would rarefy it and cause it to be exhaled into the Air. For Sir *Isaac Newton* has proved from Experiments, that Salts are composed of Acid and Earth united by Attraction: Whence it follows, that the Formation of Nitre on the Sides of plaistered Walls and on the Mortar of Brick Walls defended from Rain and Sun, must be owing to acid Parts of the Air uniting with the earthy ascalious Parts of the Lime, by the strong Attraction which intercedes them: And therefore the Air abounds with acid Particles.

The third Particular proved by Experiments entirely agrees with Sir *Isaac Newton's* Reasoning from the same Experiments, which I shall set down in his own Words. “ Also  
 “ some sulphureous Steams, at all  
 “ Times when the Earth is dry,  
 “ ascending into the Air, ferment  
 “ there

“ there with nitrous Acids, and  
 “ sometimes taking Fire, cause  
 “ Lightning and Thunder and  
 “ fiery Meteors. For the Air a-  
 “ bounds with acid Vapours fit to  
 “ promote Fermentations, as ap-  
 “ pears by the rusting of Iron and  
 “ Copper in it, the kindling of  
 “ Fire by blowing, and the beat-  
 “ ing of the Heart by means of  
 “ Respiration.” *Opt. p. 355. -----*  
 “ And the Cause of Fermentation,  
 “ *which is an Acid*, by which the  
 “ Heart and Blood of Animals are  
 “ kept in perpetual Motion and  
 “ Heat.” *Opt. p. 375.*

But this Author says, p. 75. *'Tis*  
*well known, that all Fluids, Acids as*  
*well as others, excepting Oil, will ex-*  
*tinguish Fire, and that there is no-*  
*thing in Nature but Oil that Fire can*  
*feed upon; for when the volatile and*  
*fixed Oil of any combustible Substance*  
*is consumed and evaporated, the Fire*



can act no longer upon what remains, how much soever it may be assisted and supply'd with Air: Acids will check and extinguish Fire sooner than common Water, and any acid Vapour in the Air is more suffocating and destructive than any common watry Vapour and Fume. I grant that Fire and Flame cannot subsist without oily and sulphureous Particles, neither can they subsist without an Acid; for there was an Acid in all the Mixtures of the Experiments under the third Head: So that by those Experiments both an Acid and an Oil are necessary to the Production and Preservation of Fire and Flame. But to go on, he says, *that all Fluids, Acids as well as others, except Oil, will extinguish Fire.---And that Acids will check and extinguish Fire sooner than common Water.* And what then? will it from thence follow, that a nitrous Acid cannot when mix'd with some Oils  
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in a certain Proportion produce Fire and Flame? By no means. For it has been found by Experiments, that if two Parts of compound Spirit of Nitre be poured on one Part of Oil of Cloves or Caraway Seeds, or of any ponderous Oil of vegetable or animal Substances, and particularly Oil of human Blood, or Oil of Turpentine thickened with a little Balsam of Sulphur, the Liquors grow so very hot in mixing, as presently to send up a burning Flame. *Opt. Newt. p. 353. Phil. Trans. N. 213. p. 200.* And therefore, this acid Spirit must be allow'd to have a Power of producing Heat and Flame when mixed with certain oily and sulphureous Substances in a certain Proportion: And so likewise may the nitrous Acid of the Air have a Power of preserving Fire and Flame in sulphureous and unctuous Substances when kindled, and of keeping  
ing

ing up a gentle Heat in the Blood of Animals by mixing with it in the Lungs, and fermenting with its oily Parts; and that in fact it does so, the Experiments by me alledged have fully proved.

And I am still farther convinced of the Necessity of allowing an Acid in the Air to preserve the Life of Animals, when I consider the Insufficiency of all other Accounts of *Respiration*. As to the Use assigned to the Air by this Gentleman, namely, *that it serves as a proper exhaling Medium to receive and carry off those copious Discharges of humid Effluvia or moist Vapour, which all living Creatures, and all combustible Matter under the Action of Fire, are incessantly emitting and throwing out*; I must beg leave to tell him, that this is an old trite Hypothesis, without any the least Foundation from Reason, and Experiments. For Va-  
pours



pours and Exhalations are not thrown off from humid Bodies by any Virtue in the Air, but by the repulsive Powers of their Particles, when by the Action of Heat, they are once separated from the Bodies, and are got beyond the Spheres of their Attractions and of the Attractions of one another. For this repulsive Power will carry off the separated Particles, as well *in vacuo* as in the open Air.

I could have wish'd Dr. *Morgan* had considered my *Animal Oeconomy* with a little more Temper as well as Care, and then I am satisfied he would have saved both himself and me some Trouble. It is however some Satisfaction to me, that he has given me an Opportunity of publicly declaring my self,

*Sir, Your most Obligated,*

*July 12. 1735.*

*Humble Servant,*

BRYAN ROBINSON.

F I N I S.



E R R A T A.

**P**AGE 10. l. 5. *for If A, read If a.*  
p. 32. l. 11. *after Water, read*  
However I will grant that F is ever  
as D<sup>r</sup>H, and accordingly consider  
the Consequences he draws from it.  
p. 33. l. 3. *del. ing.*



# ERRATA.

P. 10. l. 5. for If A r. If a. p. 16. l. 20. and p. 17.

l. 2. for  $\frac{Q}{.7853816D^2T} \cdot \frac{Q}{.78539816D^2T}$

ibid. for  $67.97239 \sqrt{\frac{A^2H}{A^2-a^2}}$  r.  $53.3854 D^2T$

$\sqrt{\frac{A^2H}{A^2-a^2}}$ , and for  $W = 53.38426 D^2T \sqrt{\frac{A^2H}{A^2-a^2}}$

r.  $W = 28.1756 D^2T \sqrt{\frac{A^2H}{A^2-a^2}}$ . p. 32. l. 8.

for inside r. Side. ibid. l. 11. for Water. r.

Water: And therefore the Force generating the Motion of Water flowing through a Pipe is equal to the Weight of a Cylinder of Water

whose Magnitude is  $a \times \frac{A^2H}{A^2-a^2}$ , and is propor-

tional to  $D^2 \times \frac{A^2H}{A^2-a^2}$ . However I will grant

that F is ever as  $D^2H$ , and accordingly consider the Consequences he draws from it. p. 33.

l. 3. del. ing, p. 50. l. 12. for ascalious r. alcalious.



